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EPARTMENT OF THE ARMY TECHNICAL MA

CABLEWAYS, TRAMWAY AND SUSPENSION BRIDGES

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CABLEWAYS, TRAMWAYS, AND SUSPENSION BRIDGES

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CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Purpose and Scope

a. This manual serves as a guide and reference for the erection, operation, and maintenance of military tramways, cableways, and suspension bridges. Standard cableway and tramway sets are covered to include the capabilities and characteristics of the equipment, detailed erection procedures and operating techniques. Expedient cableway, tramway, and suspension bridge design and construction methods are also covered. General principles on use of cable, methods of anchoring, use of timber and trees, and other common subjects are discussed.

b. Information in this manual is applicable to both nuclear and non-nuclear warfare.

c. Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded to the Commandant, U.S. Army Engineer School, Fort Belvoir, Va., 22060.

Section II. CROSSING METHODS

2. Basic Considerations

The success of a military mission is often dependent on the ability to move men, equipment, and supplies across rugged terrain where roads and bridges are nonexistent. In many cases the use of aircraft to overcome these obstacles is not practicable due to the adverse weather and terrain conditions. Where the capabilities for transportation by other means become extremely difficult or impossible, cable type crossings can usually be used.

a. Several issue sets have been designed and made available for constructing cableways or tramways to meet various crossing problems. A casualty evacuation set, a pioneer light aerial tramway M1,

a prefabricated light aerial tramway M2, and a prefabricated medium cableway are available. Each is designed to fit specific needs and to be quickly erected under almost any condition.

b. Where movement of a large number of personnel are involved, cableways or tramways will not accomplish the job; therefore, a suspension bridge may have to be constructed.

c. The conditions which create the need for the installation may also make it impossible to obtain one of these issue sets in the time available. Under such circumstances an expedient suspension bridge, cableway, or tramway must be designed and erected in the field using improvised components. For this reason, expedient design and construction are discussed in this manual.

3. Cableway

A cableway (fig. 1) consists of a fixed track cable supported at both ends in a single span without intermediate supports and carrying a trolley, which is hauled back and forth on the track cable to move the load from one end of the span to the other. A cableway can be used to transport personnel or supplies, and can be used to span any gap where intermediate high points will not prevent trolley movement. For this reason, it normally is used to span a single stream, gorge, ravine, or marshy ground. The length of span and maximum weight of a single load are determined by the strength of the track cable, the amount of sag, and the tower strength.

4. Tramway

A tramway (fig. 2) consists of a fixed track cable supported at both ends and carrying a trolley with intermediate towers to provide clearance at high points along the route. The trolley is hauled back and forth on the track cable to move the load. Because of the intermediate towers, the tramway may traverse steep slopes and several streams or gorges, covering thousands of feet in total length of haul. Several parallel track cables may be used on one series of towers. The length of the longest span and maximum weight of a single load are determined by the strength of the track cable, the amount of sag, and the tower strength.

5. Monocable

A monocable (fig. 3) consists of a continuous track cable supporting a carrier in a fixed position on the cable. The cable is supported at both ends by blocks. In operation, the cable moves back and forth through the blocks, causing the carrier to move from one end of the span to the other. A monocable normally is used for light loads being moved across short spans, as in casualty evacuation. Gravity is frequently used to move the load when all movements are from the upper terminal to the lower terminal.

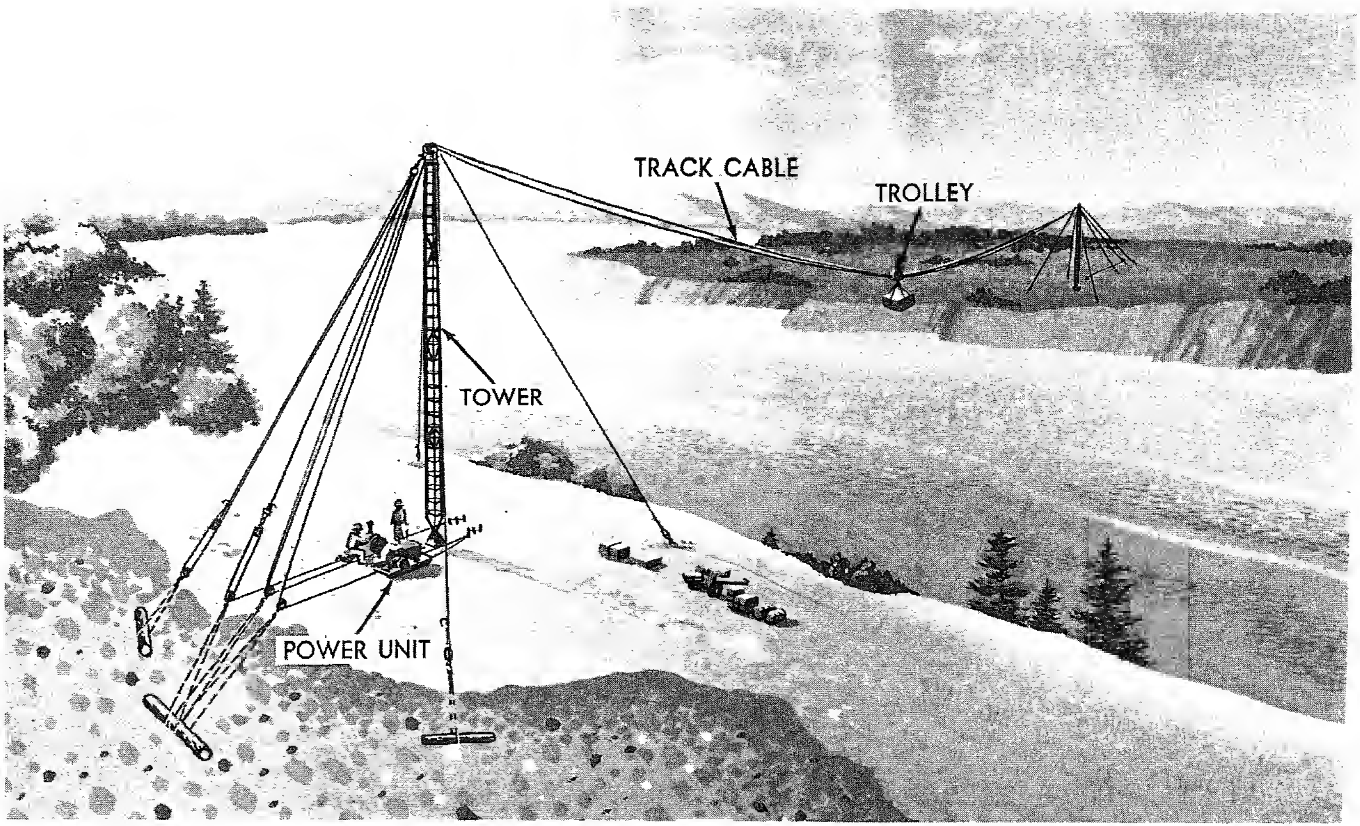


Figure 1. General viev   ıedium cableway.

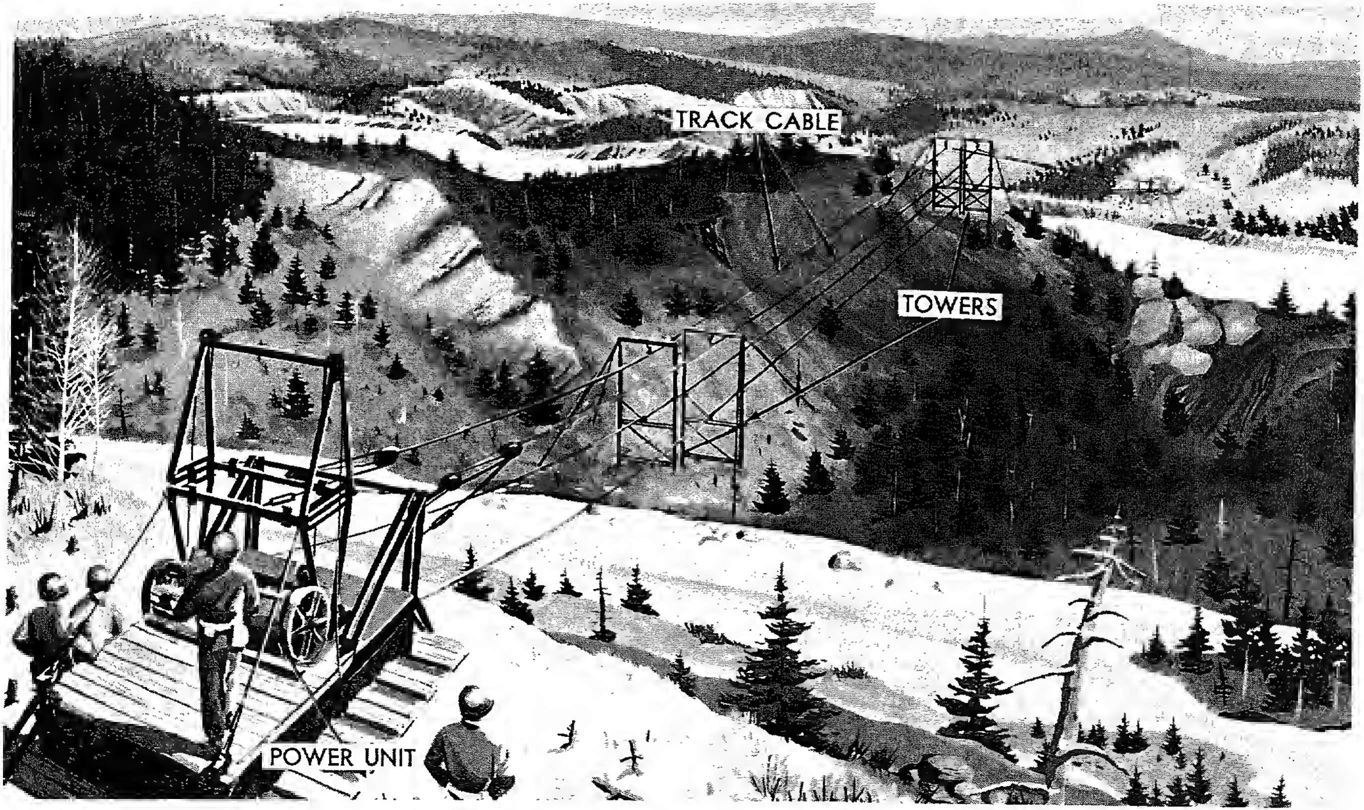


Figure 2. General view of aerial tramway.

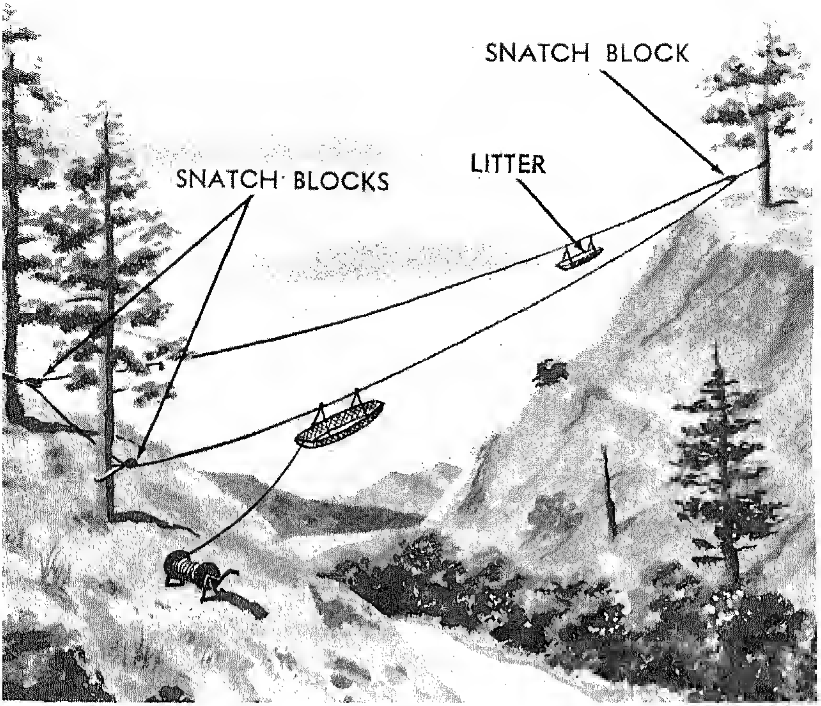


Figure 3. Typical monocable operation.

꞉uspension Bridge

suspension bridge (fig. 4) consists of a roadway suspended between or more main cables passing over towers and securely anchored at ends. They have several advantages over the other military ges. For a given capacity they are lighter in weight, can span up to 400 feet without intermediate supports, and with the ption of cables, can be constructed from local materials. Only ively light loads, however, can be carried. The length of span maximum load are determined by the strength of the cable, sag, er strength, and dead load of the roadway.

omenclature

Cableways. In general terms, the components of a cableway em include a track cable supported at the ends by towers (fig. 5), olley and carriage pulled along the track cable by a haul rope, and wer unit to operate the haul rope. The towers must be supported uylines at most installations and may require saddles or sheaves which the track cable and haul rope pass. The ground end of guyline is fastened to an anchorage. The end of the track cable nd each tower is fastened to an anchorage. At one tower a system locks, called takeup gear, is inserted between the track cable end

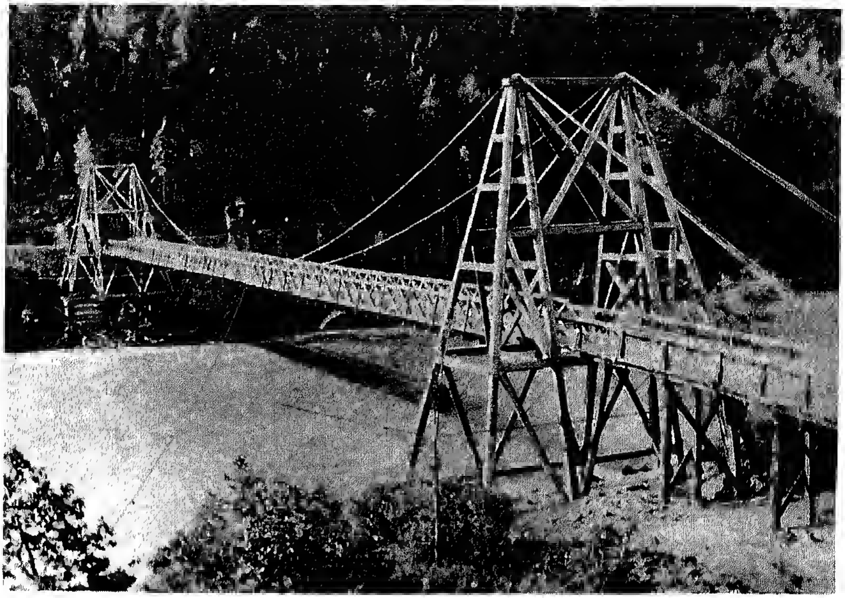


Figure 4. General view of a suspension bridge.

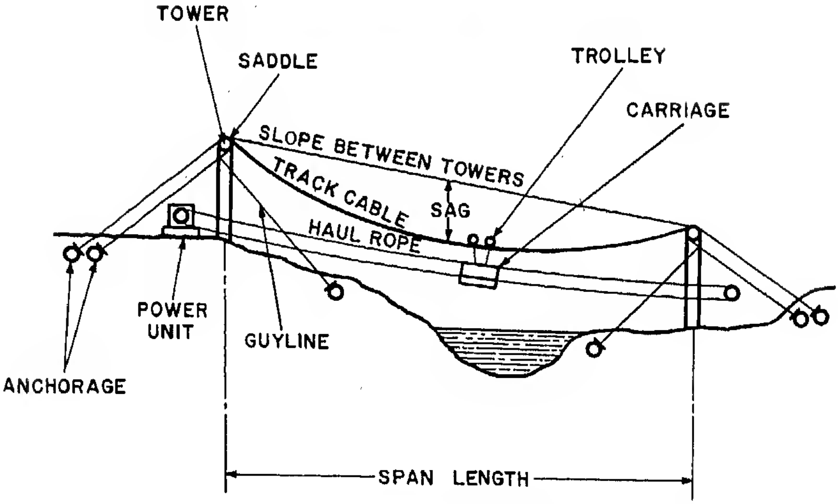


Figure 5. Nomenclature of components of a cableway system.

and the anchorage. This takeup gear is used to adjust the tension in the track cable. Between the towers, the track cable hangs in a curve, caused by the weight of the cable and the weight of the suspended load. The distance between this curved line and a straight line between the track cable supports is called sag. Hauling in on the takeup gear increases the tension in the track cable and decreases

the sag. When a load is added to the track cable by suspending the load from the trolley, either the tension in the cable or the sag, or both, are increased.

b. Tramways. The same nomenclature as in *a* above is used for the components in a tramway. However, additional towers are placed between the two end towers in a tramway installation. These additional towers are called intermediate towers. The track cable passes over a saddle at each intermediate tower. The saddle is supported on a C-shaped hanger, so that the trolley, which rolls along the top of the track cable, can pass the tower without leaving the track cable or striking the supports.

c. Suspension Bridges. In general terms, the components of a suspension bridge include the main cables supported at the end by towers (fig. 6) and a roadway suspended from the main cables by suspender cables. The suspender cables are attached to floor beams which support the stringers on which the decking of the roadway is placed. To stiffen the bridge and spread the live load to several suspenders, a stiffening truss consisting of a side rail and cross braces is usually added. The main cables are fastened to anchorages at both ends. The section of cable between the tower and the anchorage is called the backstay. Sag and span are the same as cableways. Camber is the vertical distance from the top of the floor in the middle of the span to a straight line drawn between the tops of the tower sills. Cradle is the lateral distance from the midpoint of the main cable to the straight line drawn between its points of support on the towers. Flare is the lateral distance from the cable support on the towers to the cable at the anchorage. Flare and cradle increase the lateral stability of the suspension bridge.

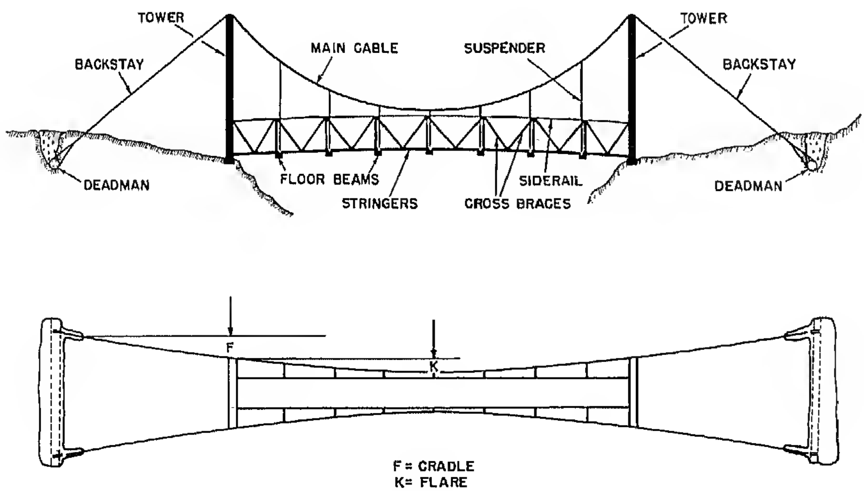


Figure 6. Nomenclature of a suspension bridge.

Section III. SELECTING SIZE AND TYPE OF INSTALLATION

8. Requirements

Before selecting the actual size and type of installation, make a visual survey of the general area. The terminals must be accessible so that materials for transportation can be moved to them. If possible, the tower sites should be relatively free of trees and brush. A site where only a small amount of clearing is required will be less noticeable from the air and will require less preparatory work. Other pertinent criteria are as follows:

a. Cableway. For expedient cableways, the distance between towers should be kept as short as possible, not to exceed 2,500 feet. The difference in elevation of the towers should also be kept as small as possible. Long spans with considerable difference in elevation require large size wire ropes, and increases the problem of obtaining necessary materials. The greater tension in the cable requires heavier towers and anchorages, increasing the problems of construction. Spans of 1,000 to 1,500 feet are much less difficult to erect. High points between towers must be avoided because the cable must sag between towers and this will require construction of high towers to provide clearance. At the site for the individual towers, a fairly level space is required large enough for loading and unloading on the cableway side of the tower. For clearance reasons, it is best if the ground slopes sharply away from the loading area on the cableway side. The tower guylines must be anchored (fig. 7) and so must the track cable. Space for a power unit must be provided at the operating terminal, usually the lower terminal, and for some installations a hoist unit will be required.

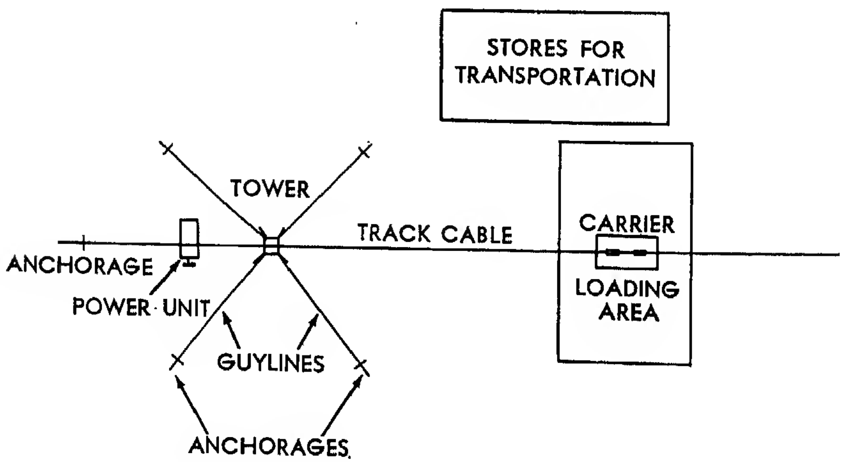


Figure 7. Typical plan at area of tower.

b. Suspension Bridge. The spans of suspension bridges should be kept below 400 feet. Greater spans will require larger cables which normally are not available and a greater span will also tend to make the bridge unstable. Bridges with slopes over 10 percent are difficult to cross and construct. The problems with tower and anchorage construction also increase with the size of the bridge.

9. Profile of Terrain

Wherever possible, a survey of the site should be made to determine the profile. An elaborate survey is not necessary but a stadia survey is sufficiently accurate. If surveying instruments are not available, a rough profile can be drawn based on a reconnaissance trip along the centerline of the proposed installation. The profile will greatly assist the planning of cable sag and tower heights. For cableways or tramways, the elevations of the high points are of great importance due to the clearance problems, and should be carefully estimated if the reconnaissance method is used. A profile sketch should be drawn to a convenient scale (fig. 8).

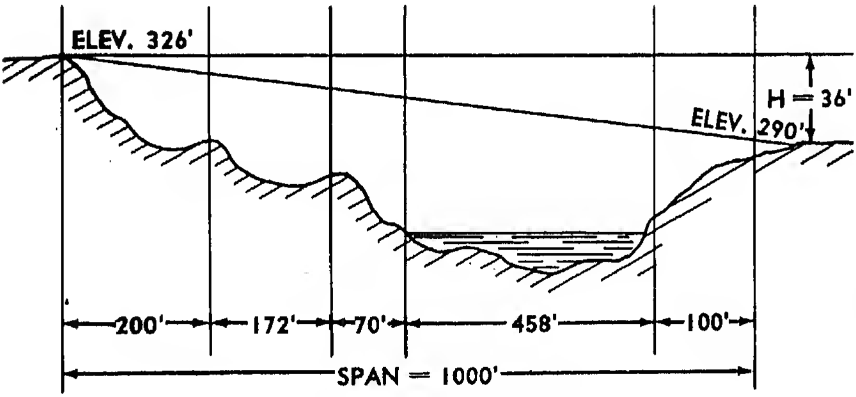


Figure 8. Typical field profile.

10. Selecting Installation

In selecting an installation, consider the requirements established by the field profile and the type and volume of materials to be moved. If the requirement is for movement of personnel or light equipment and the gap is not too great, a suspension bridge will be the best installation. The load and span will determine the type and size of suspension bridge to be constructed. When selecting a cableway or tramway, for simplicity and speed, an issue set should be used whenever possible. Issue sets are available for quick erection of cableways and tramways to meet specific purposes, as shown in table I. The medium cableway and M2 sets include prefabricated towers.

Towers for the M1 and casualty evacuation sets must be erected from native materials. If sets are not available, an expedient installation, which is discussed in chapter 4 must be made.

Table I. Issue Sets for Cableways

Item	Maximum Span (ft)	Maximum Payload (lb)
Casualty evacuation set	1, 000	200
Tramway set, aerial M1	1, 500	2, 000
Tramway set, aerial M2	3, 000	350
Cableway set, aerial	1, 200	3, 000
Tramway extension set	[1]	[1]

[1] This set consists of components required to extend the aerial tramway set M2 an additional 1,000 feet.

CHAPTER 2

WIRE ROPE CABLES

Section I. CHARACTERISTICS, CARE, AND HANDLING

11. Introduction

Although wire rope is used for the actual installation of cableways and tramways, fiber rope is used extensively for their erection. Th following presents a brief summary of the characteristics, care, an handling of both wire and fiber rope. A more detailed coverage is given in TM 5-725.

12. Characteristics

a. Strand Combinations. Wire rope is classified by the number of strands, number of wires per strand, size, and material. When giving the type, 6 x 7 or 6 x 19 refers to the number of strands per rope and the number of wires per strand; i.e., for 6 x 19 there are 6 strands per rope, 19 wires per strand (fig. 9),

b. Materials. The material from which the wire rope is manufactured affects its strength. The most common are improved plow steel, plow steel, mild plow steel, and iron. Normally, improved plow steel is used for cableways and suspension bridges.

c. Size. The size of wire rope is designated by its diameter in inches. To determine the size of a wire rope, measure its greatest diameter (fig. 10).

d. Weight. The weight of wire rope varies with its size and type of construction.

e. Strength. The strength of wire rope varies with the size, type of material from which constructed, and type of construction. The breaking strength in tons is divided by the safety factor to give the working capacity. The safety factor for cableway is generally 3.5; for suspension bridge main cables, it is usually 4.

13. Coiling and Uncoiling

New fiber rope is coiled into bales of about 1,200 feet each. The bales are bound and wrapped in burlap. To open a new coil, strip off the burlap wrapping and look inside the coil for the end of the rope, which is usually at the bottom. Cut away the binding on the

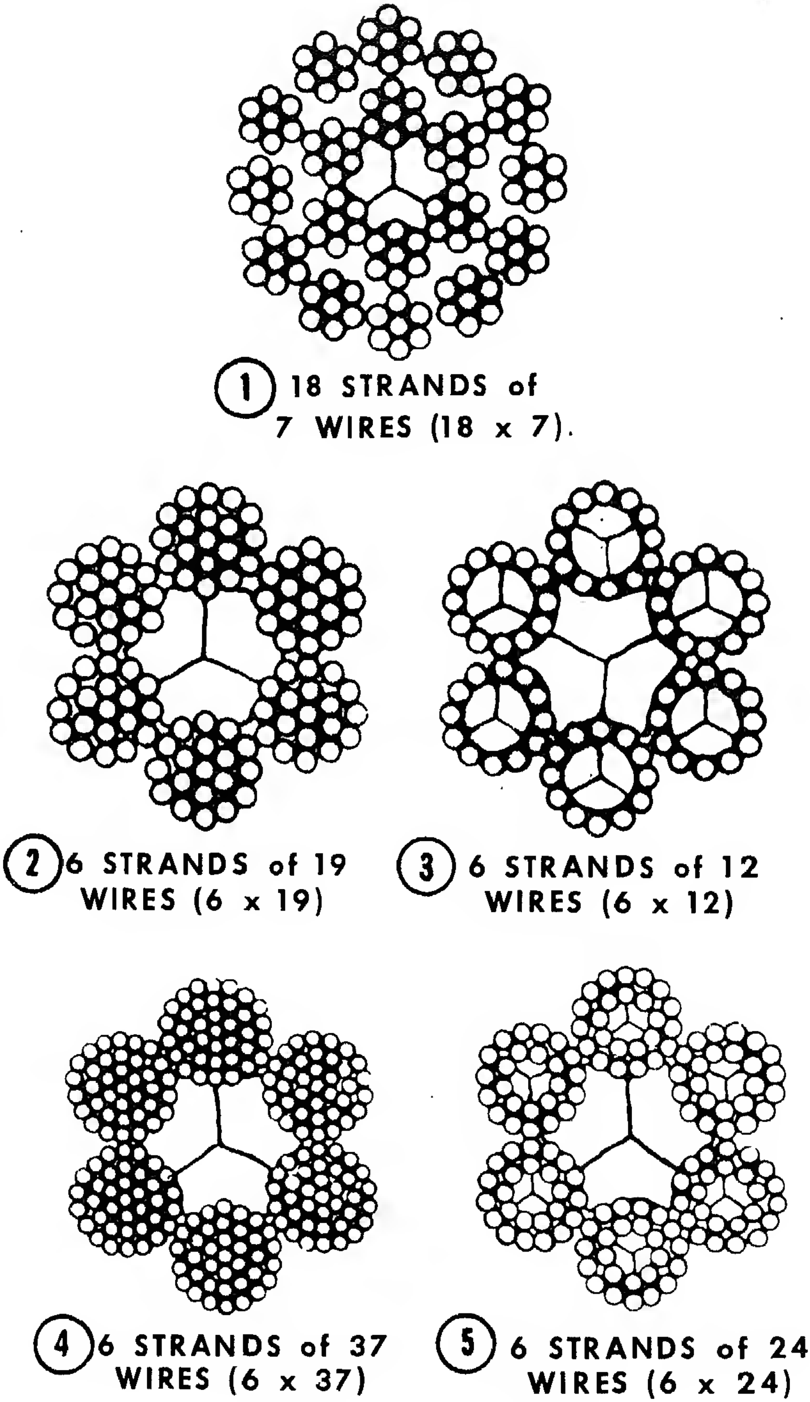


Figure 9. Wire rope construction.

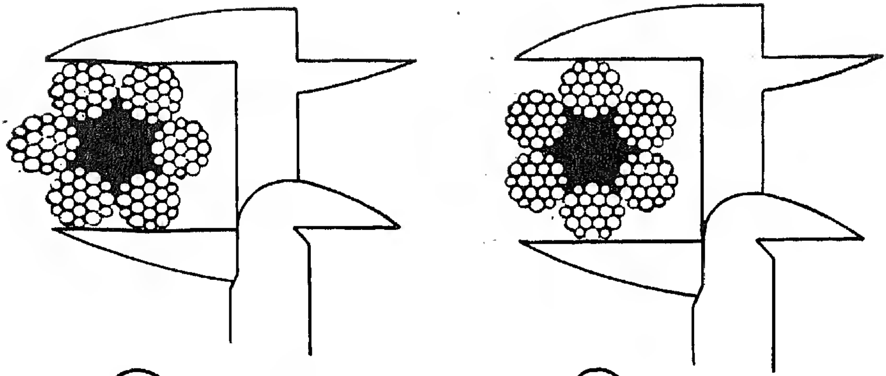


Figure 10. Measuring diameter of wire rope.

coil and pull the end of the rope up through the center of tl Wire rope is much stiffer and more difficult to handle than fibe Loose wire rope should be coiled in a manner that preven loops from forming. Left lay wire rope should be coiled in a clockwise direction and right lay wire rope should be coil clockwise direction. Straighten out all loops before coiling past them. These small loops cannot be straightened by pulling the rope taut. Twist the rope to remove them. Do not attempt to uncoil or unreel wire rope from a stationary coil or reel, as this will cause kinking. Rotate the reel or coil. The most satisfactory method of unreeling wire rope (fig. 11) is to mount the reel on a pipe or rod supported by two uprights. As the wire rope is pulled away from the reel, the reel will turn, keeping the wire rope straight. If wire rope is in a small coil, stand the coil on end (fig. 12) and roll it along the ground.

14. Attachments

a. Methods of Joining. To obtain maximum strength at any joining of wire rope ends, each end should be made up into an eye splice (fig. 13), an end fitting should be attached, or wire rope clips or clamps may be used to make an eye. The wire rope can then be joined to another wire rope, a hook, a ring, or a link of chain directly or by using a shackle. An end fitting can be placed directly on wire rope. Permanent end fittings include closed and open basket sockets and bridge sockets. Wedge sockets are easy to install and may be quickly changed (fig. 14).

b. Wire Rope Clips. Wire rope clips (1, fig. 15) may be used in making up eyes in wire rope, either for a simple eye or for an eye reinforced with a thimble. A thimble-reinforced eye can be made with wire rope clips which will have about 80 percent of the strength of the

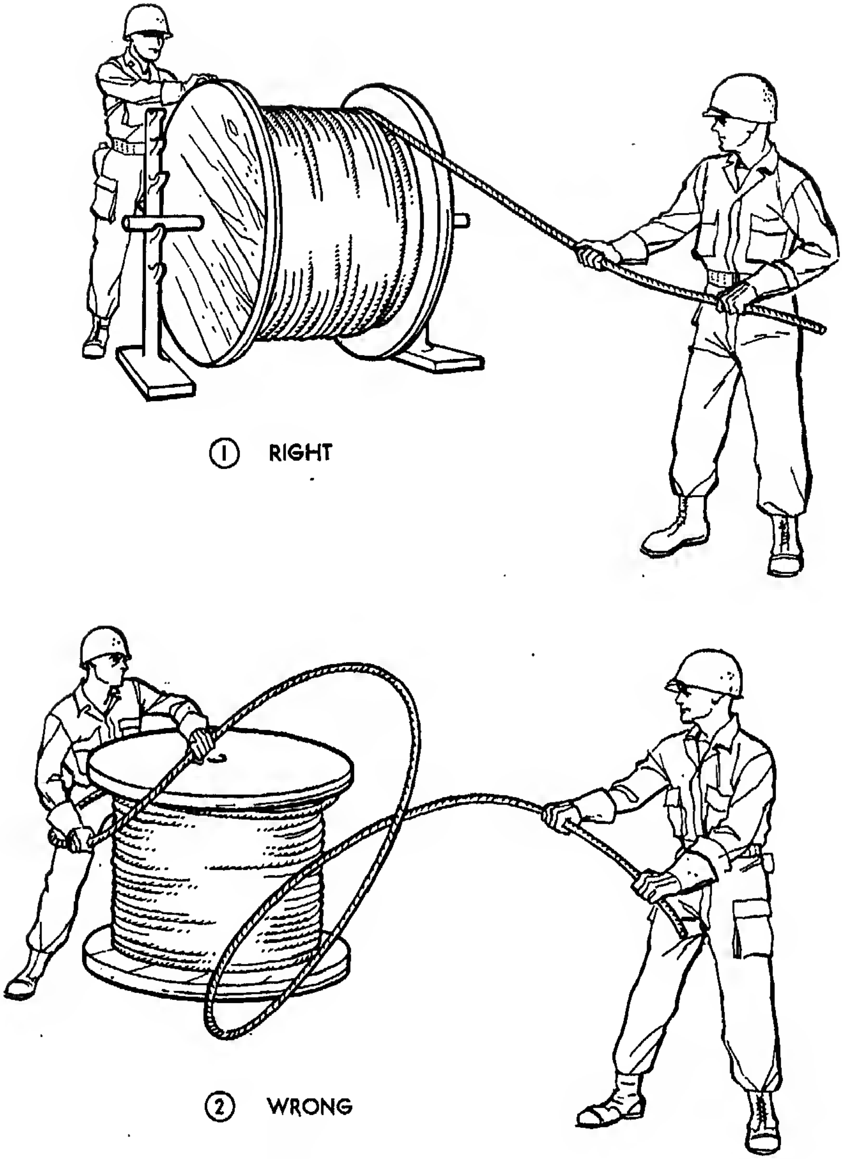


Figure 11. Unreeling wire rope.

rope. Place the back of the thimble against the wire rope, leaving sufficient free room to allow for the proper number and spacing of clips. Bend the wire rope around the thimble and install a clip close to the pointed end of the thimble where the two parts of the wire rope come together. Slip the U-bolt of the clip over the free end (short end) of the rope. This is done because there is less holding surface on the U-bolt than on the base and the principal tension will occur on the

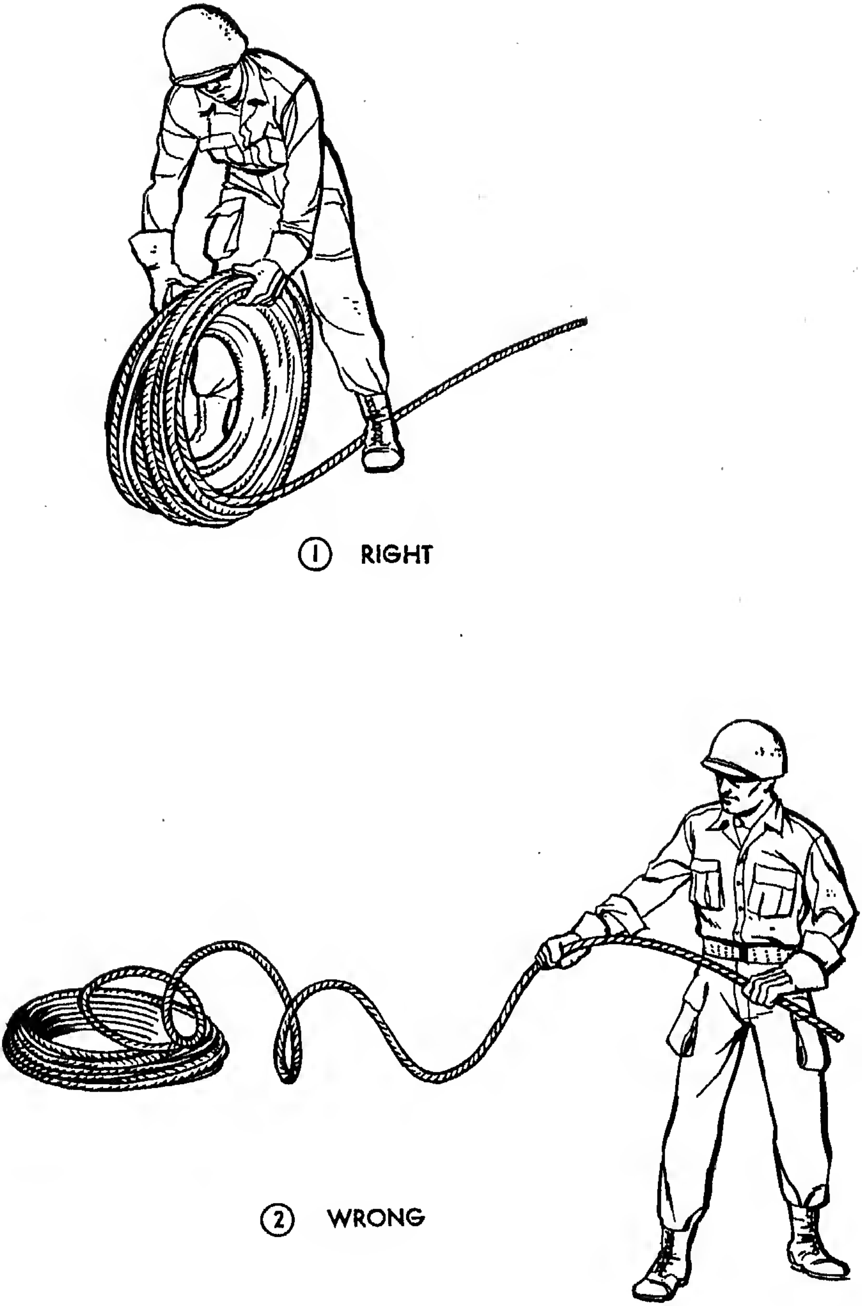


Figure 12. Uncoiling wire rope.

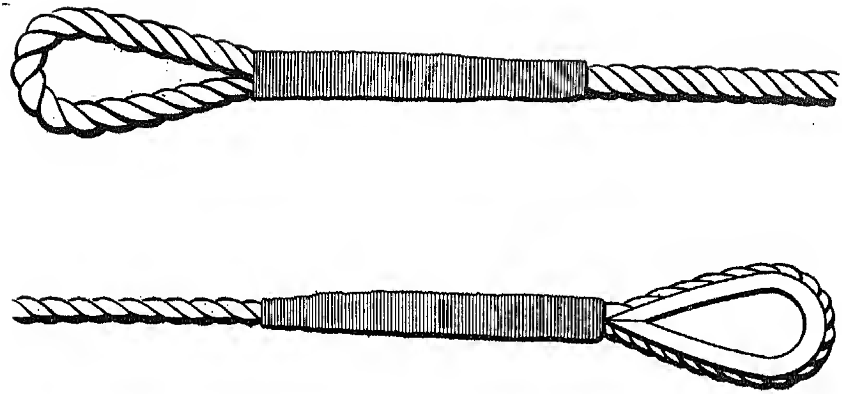


Figure 13. Finished eye and thimble splices.

ıg end of the rope. The clips should be spaced about six rope ımeters apart for the best service. The minimum number of clips be installed is equal to three times the diameter of the rope plus one. hen the calculation results in a fraction, use the next larger whole mber.

ample:

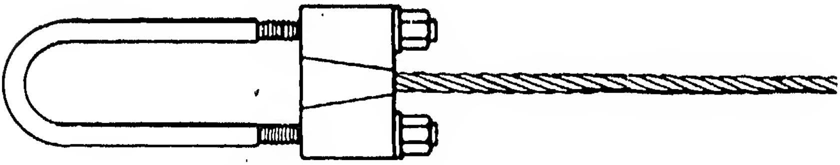
For ¾-inch diameter cable:
3 (¾)+1=2.25+1=4 clips.
For clip spacing:
6 (¾)=4.5.
Use 4 clips spaced 4½ inches apart.

c. Wire Rope Clamps. A wire rope clamp (②, fig. 15) can be used with or without a thimble to make an eye in wire rope. It has about 90 percent of the strength of the rope. To install a wire rope clamp slip the two end collars of the clamp on the rope, facing each other, before forming the eye. Bring the free end of the wire rope back and slip one end collar over both parts of the rope so that the free end of the rope is just even with the ends of the two side pieces. Both ends of each side piece are tapered. When the end collars are screwed on them, the two side pieces are tightened against the two parts of the rope. Tighten the two end collars with wrenches to force the clamp to a good snug fit.

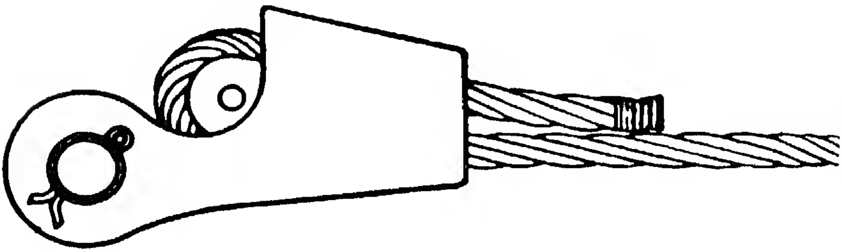
d. Knots. Knots cause excessive fatigue in wire rope and are not very strong. They should be avoided. When wire rope fittings are not available and it is essential to use a knot, a fisherman's bend, a clove hitch, or a carrick bend can be used. The free end of the rope must be fastened to the standing part after the knot is tied. A wire rope clip, if available, is best for this. However, a strand of wire can be tied around the two parts of the wire rope to hold the end. All knots in wire rope should be checked frequently for signs of wear or breakage.

(1) CLOSED SOCKET

(2) OPEN SOCKET

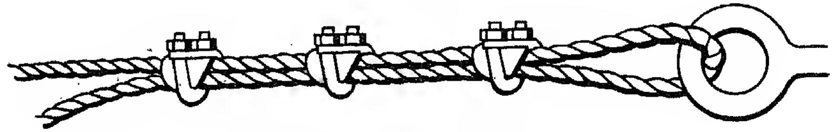


(3) BRIDGE SOCKET

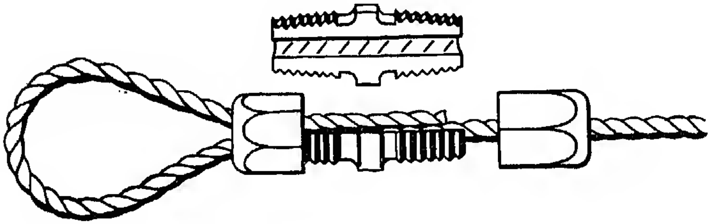


(4) WEDGE SOCKET

Figure 14. Types of wire rope and fittings.



① WIRE ROPE CLIPS



② WIRE ROPE CLAMP

Figure 15. Method of attaching wire rope clips and clamps.

When the rope does show wear, cut a short piece off the end and tie a new knot in the fresh end.

15. Handling

a. Seizing. Before cutting wire rope, seize the place where the new ends will be to prevent them from untwisting. Seizing is the most satisfactory method of binding the end of a wire rope, although scrimping or welding will hold the ends together satisfactorily. The seizing will last as long as desired, and there is no danger of weakening the wires through the application of heat. To seize wire rope, wind annealed iron wire around the rope by hand, keeping the turns tight (①, fig. 16) and considerable tension on the wire. After several turns have been taken about the wire rope, twist the ends of the binding wire together in a counterclockwise direction (②, fig. 16) so that the twisted portion of the wires is near the middle of the seizing. Tighten the twist with nippers (③, fig. 16) to take up the slack. Do not attempt to tighten the seizing itself by twisting the ends; tighten the seizing by prying the twist (④, fig. 16) in the wire away from the wire rope. Then again tighten the twist with nippers (⑤, fig. 16). Repeat this as necessary to make the seizing tight. Cut off the ends of the wires and bend the twisted portion down against the rope (⑥, fig. 16). There are three convenient rules for determining the number of seiz-

ings, lengths, and space between seizings. In each case when the calculation results in a fraction, the next larger whole number is used.

(1) The number of seizings to be applied equals approximately three times the diameter of the rope.

Example:

$3 \times \frac{3}{4}$ (dia) $= 2\frac{1}{4}$. Use 3 seizings.

(2) Each seizing should be 1 to $1\frac{1}{2}$ times as long as the diameter of the rope.

Example:

$1 \times \frac{3}{4}$ (dia) $= \frac{3}{4}$. Use 1-inch seizings.

(3) The seizings should be spaced a distance apart equal-to twice the diameter.

Example:

$2 \times \frac{3}{4}$ (dia) $= 1\frac{1}{2}$. Use 2-inch spaces.

b. Cutting. Wire rope may be cut with rope cutter, a cold chisel, a hacksaw, bolt clippers, or an oxyacetylene cutting torch. Before cutting the wire rope, it should be seized (*a* above) to prevent unlaying of the rope. Use three separate seizings on each side of the cut. To use the wire rope cutter (fig. 17), insert the wire rope in the bottom of the cutter with the blade of the cutter coming between the two central seizings. Push the blade down against the wire rope and strike the

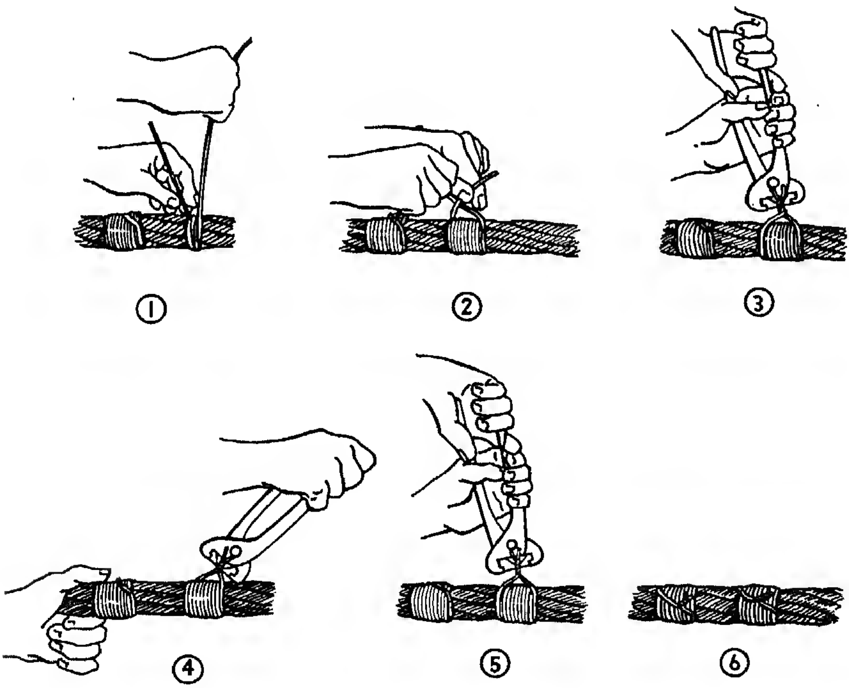


Figure 16. Seizing wire rope.

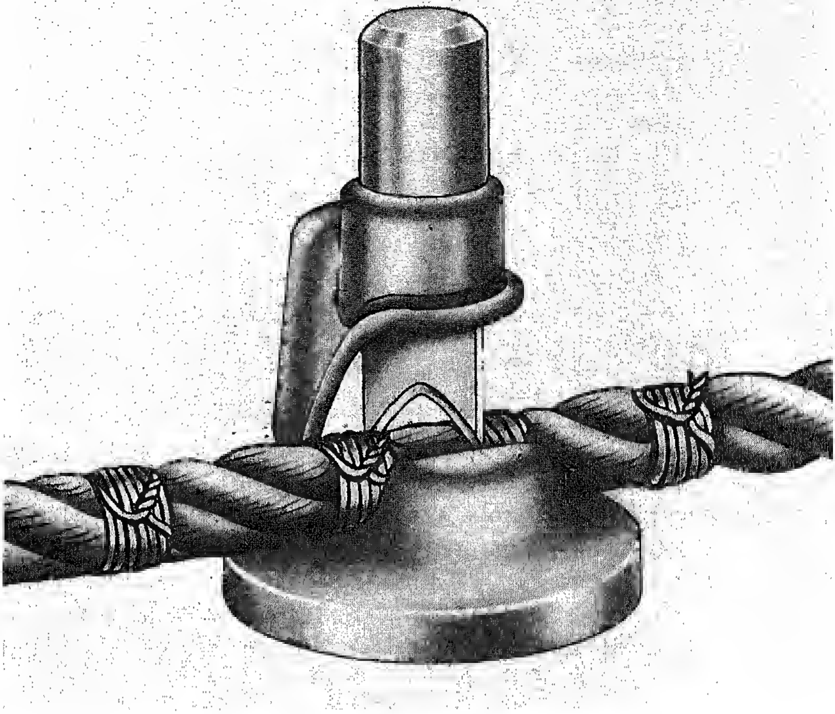


Figure 17. Use of wire rope cutter.

top of the blade sharply with a sledge hammer several times. The bolt clippers can be used only on wire of fairly small diameter, but the oxyacetylene torch can be used on wire of any diameter. The hacksaw and cold chisel are slower methods of cutting.

c. Cleaning. Used wire rope should be carefully cleaned of any accumulation of dirt, grit, or other foreign material before using it again. Rust should be removed from installed wire rope at regular intervals by wire brushing. Scraping or steaming will remove most of the dirt or grit which may accumulate on the wire. A liberal amount of detergent in hot water makes a good cleaning agent, particularly when used with a stiff bristled scrubbing brush. However, such cleaning removes all of the old lubricant. The wire rope must be completely dried and lubricated again before storage or reuse. The rope should always be carefully cleaned just prior to lubrication. The object of cleaning at that time is to remove all foreign material and old lubricant from the valleys between the strands and from the spaces between the outer wires to permit the newly applied lubricant free entrance into the rope.

d. Lubrication. At the time of fabrication a lubricant is applied to wire rope. This lubricant generally is not sufficient to last through-

out the life of the rope, making it necessary that the lubricant be renewed periodically. A good grade of oil or grease can be brushed on the rope, or the lubricant can be applied by passing the rope through a trough or box containing the lubricant. The wire can be wiped down with a rog soaked in lubricant, although this is slower. The application of the lubricant should be made as uniform as possible throughout the length of the rope. The lubricant used should be free of acids and alkalies and should be light enough to penetrate between the wires and strands of the rope. In every case where the wire rope is being stored for any length of time it should be cleaned and lubricated prior to storage.

16. Inspection

a. Fiber Rope. Fiber rope should be inspected carefully at regular intervals to determine its exact condition. Since the surface appearance of the rope is not a good indication of its condition, the strands should be untwisted slightly to open the rope so that the inside can be examined. Mildewed rope will have a multy odor and inner fibers will have a dark stained appearance. Broken strands or broken yarns ordinarily are easy to find. In rope having a central core, the core should not break away in small pieces upon examination. Examine the rope at a number of places, as any weak spot will weaken the entire rope. Pull out a couple of fibers and try to break them. Sound fibers should offer considerable resistance to breakage.

b. Wire Rope. Wire rope should be inspected at frequent intervals and frayed, kinked, worn, or corroded rope replaced. The frequency of inspection is determined by the amount of use of the rope. The weak points in the rope, or the points where the greatest stress occurs, should be inspected with great care. In general, examine the rope for worn spots and broken wires. Worn spots will show up as shiny flattened spots on the wires. Measure some of these shiny spots. If it appears that the outer wires have been reduced in diameter by one-fourth, the worn spot is unsafe. There may be several points in the rope where broken wires occur. Inspect each point to determine whether it is a single broken wire or several. If several wires are broken next to each other, unequal load distribution at this point will make the rope unsafe. When 4 percent of the total number of wires in the rope are found to have breaks within the length of one rope lay, the rope is unsafe. Consider the rope unsafe if three broken wires are found in one strand of 6 x 7 rope, six broken wires are found in one strand of 6 x 19 rope, or nine broken wires are found in one strand of 6 x 37 rope.

17. Storage

When rope is being stored, care should be taken to prevent deterioration of the rope. Do not store fiber rope in wet or damp

places; dry it carefully before storing. If possible, store fiber rope on gratings or in some other manner that will allow circulation of air through the coil. Wire rope should be coiled on a spool for storage and should be properly tagged as to size and length. It should be stored in a dry place to reduce corrosion, and kept away from chemicals and fumes which might attack the metal. Prior to storage, wire rope should always be cleaned and lubricated. If the lubricant film is applied properly and the wire rope is stored in a place protected from the weather, corrosion will be virtually eliminated. Rusting, corrosion of the wires, and deterioration of the fiber core sharply decrease the strength of wire rope.

Section II. CABLE SELECTION

18. Design Considerations

The following factors must be considered in selecting cable size.

a. Horizontal distance between towers or spans.

b. Difference in elevation between towers or slope.

c. Maximum allowable deflection.

d. Length of cable between towers.

e. Weight per foot of cable.

f. Maximum load to be supported.

g. Safety factors. For suspension bridges use 4, for cableways use 3.5.

h. Wind and ice loadings and temperature changes. In most climates these will have a nominal effect and may be disregarded but must be included where extreme conditions occur.

19. Analysis

When a cable is supported at each end and allowed to hang freely under its own weight, it forms a curve which is part of a catenary. Hauling on the ends of the cable will reduce the amount by which it sags. Therefore, the tension in the cable and the amount of sag bear a direct relation. When a load is added to the cable, such as by suspending a trolley from it, either the tension in the cable or the sag, or both, are increased. For purposes of analysis, the computations are simplified by assuming that uniform loading (the weight of the cable) is distributed horizontally and that the cable assumes a parabolic arc. The formulas used are for level spans anchored at both ends. This simplification will produce answers sufficiently

accurate for normal work without making the computations laborious. Two conditions may be involved. A uniformly loaded cable, and a uniformly loaded cable (its own weight) with a concentrated load. The first condition applies for suspension bridges or unloaded cableways, and the second for loaded cableways.

a. Uniform Load. In a level span uniformly loaded (its own weight, only) and anchored (fig. 18), the following formulas apply:

Center deflection is: $$y_c = \frac{ws^2}{8t} \qquad (1)$$

Horizontal tension is: $$t = \frac{ws^2}{8y_c} \qquad (2)$$

Tension in cable is: $$t' = t \sec \beta_1$$

Cable slope is: $$\tan \beta_1 = \frac{4y_c}{s}$$

Length of cable is: $$L = s\left(1 + \frac{8}{3} K^2\right)$$

Where: w is weight in pounds per feet of cable, s is span in feet, an is the sag ratio $\frac{y_c}{s}$.

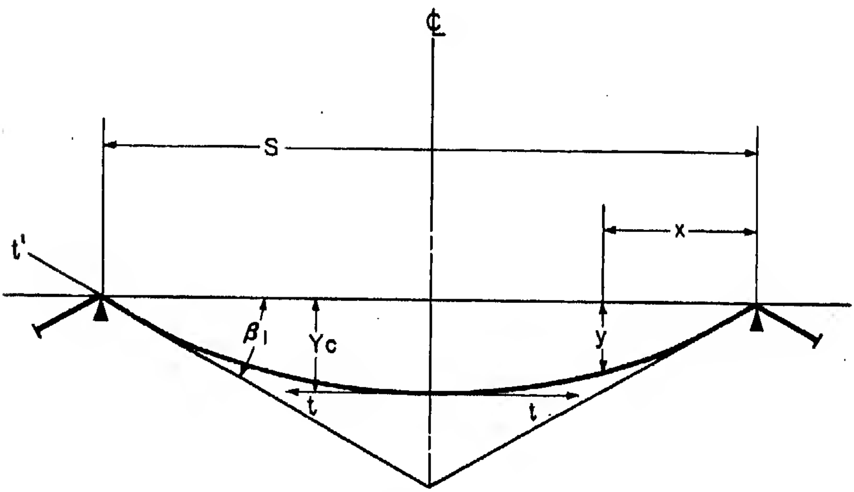


Figure 18. Symbols for analysis of anchored level span uniformly loaded.

b. Concentrated Load. In a level span uniformly loaded (its own weight) and anchored, with a concentrated load at the center (fig. 19) the following formulas apply:

Center deflection is: $$Y_c = \frac{s(2P+ws)}{8t} \qquad (6)$$

Horizontal tension is: $$t = s\,\frac{(2P+ws)}{8y_c} \qquad (7)$$

Tension in cable is: $$t' = t \sec \beta_1 \qquad (8)$$

Cable slope is: $$\tan \beta_1 = \frac{P+ws}{2t} \qquad (9)$$

Where: w is weight in pounds per foot of cable, s is span in feet, and P is load concentrated at center in pounds.

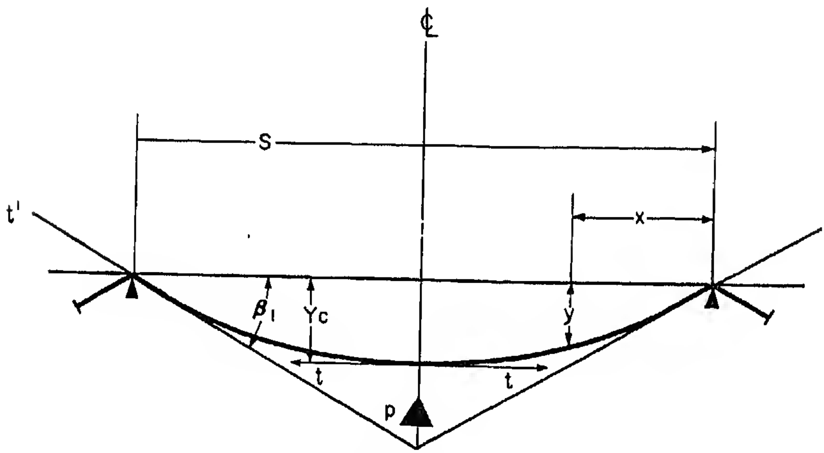


Figure 19. Symbols for analysis of anchored level span with concentrated load at center.

c. Deflection. If it is desired to compute the deflection from the chord at a point other than the centerline for purposes of determining clearances, the following formula is used. First the deflection at the center must be computed, then applied to this formula:

$$y = \frac{4y_c}{s^2}\,(sx - x^2) \qquad (10)$$

Where: y is deflection from chord to curve, and x is the distance from the nearest terminal to the point under consideration.

20. Field Design

Table II, together with the graphs in appendix III, facilitate field design of expedient cableways and suspension bridges. Table II is used for suspension bridges and unloaded cableways and the graphs for loaded cableways. Examples of their use will be covered in later chapters.

a. Use of Table. Table II, Uniformly Loaded Cable Design Data, is used to determine the tension in a cable for a given span and loading. Column (1) is the sag ratio of deflection y_c over the span s. Column (2) gives the tension in a cable when a uniform load, w, is suspended along the horizontal span, s. The tension is determined by multiplying the factor in column 2 opposite the appropriate sag ratio by ws. This column is used for suspension bridge design. Column 3 is used to determine the tension in an unloaded cableway. The weight per foot of cable w′, and the span s, are multiplied times the factor opposite the appropriate sag ratio to obtain the tension in the cable. Column 4 is used to determine the length of cable between supports by multiplying the span s, times the factor opposite the appropriate sag ratio.

Table II. *Uniformly Loaded Cable Design Data*

Factors for determining cable tension and length

(1) Sag ratio K	(2) When weight per foot of span is known t′=w's x (factor)	(3) When weight per foot of cable is known t′=w's x (factor)	(4) To get length multiply span by factor L=s x (factor)
5	2. 55	2. 55	1. 007
7	2. 14	2. 14	1. 010
8	1. 64	1. 64	1. 013
9	1. 48	1. 49	1. 017
10	1. 35	1. 36	1. 026
11	1. 24	1. 26	1. 031
12	1. 16	1. 18	1. 037
13	1. 08	1. 11	1. 043
14	1. 02	1. 05	1. 050
15	. 97	1. 01	1. 057
20	. 80	. 88	1. 098

b. Use of Graphs. Each graph in appendix III covers a specific slope ratio and sag ratio. Plotted on the graphs are lines indicating acceptable upper limits for track cable and haul rope loading. On a given graph, select the point which has an abscissa equal to the span in feet of the planned cableway. A vertical line through this point will cut the lines of track cable size at ordinates indicating maximum

allowable payload for that size cable. The remaining two grap are for obtaining ratios of unloaded to loaded sag and tension. If computation in paragraph 19*b* is used to determine loaded deflect (sag) at center, the ratios in the graphs can be applied to determ the unloaded or erection sag. If the loaded tension is determin from 19*b*, the ratios can be applied to determine unloaded or erect tension. This may be needed in order to use a tensiometer to installation tension.

19*b* use the symbol P for the load track cable at the center. Since t rriage, a portion of the weight of t load. The tension in the haul ro ratio, the position of the carriage in t nce to motion offered by the carria hese factors depend on, or affect, t y for computation has been eliminat the graphs the haul rope size applicable to a speci

CHAPTER 3

TOWERS AND ANCHORAGES

Section I. TOWER CONSTRUCTION

22. Introduction

Towers for the medium cableway and light aerial tramway M2 are prefabricated and only assembly is required at the site. Single standing trees can usually be used as towers for the casualty evacuation set. For the pioneer light cableway M1, expedient cableways, tramways, and some suspension bridges, towers must be constructed. Terminal tower construction for a cableway, tramway, or toboggan installation is identical. Intermediate towers are constructed for a tramway but are not used for a cableway or a toboggan hauling unit. After the planning of type of installation is completed and a decision has been reached as to number and height of towers, individual tower construction proceeds. At each tower location the type of tower most suited to the location is built.

23. Saddles

For heavy cables or long spans, saddles may be required to protect the timber crossmembers. The saddles may be fabricated from sheet steel or pipe. Several examples are shown in figure 20. The strap shown in ①, figure 20 can easily be fabricated from strap steel. It can be indented to position and steady the cables. A heavier plate and saddle block combination is shown in ②, figure 20. The cable is held in place by only partially driving the nails on either side of the cable. The saddle block and plate can be used on flat timbers to allow for curvature of the cable. ③, Figure 20 illustrates a saddle prefabricated from pipe. It can be used where several cables or a heavier cable is required. Saddles fabricated from ½-inch steel plate are sufficient for cables up to 1½-inch diameter.

24. Tower Erection

Members can be lifted into place by manpower for low towers. When a crossmember is to be lashed to two standing trees at a level too high for it to be erected by lifting it into place, tackle can be

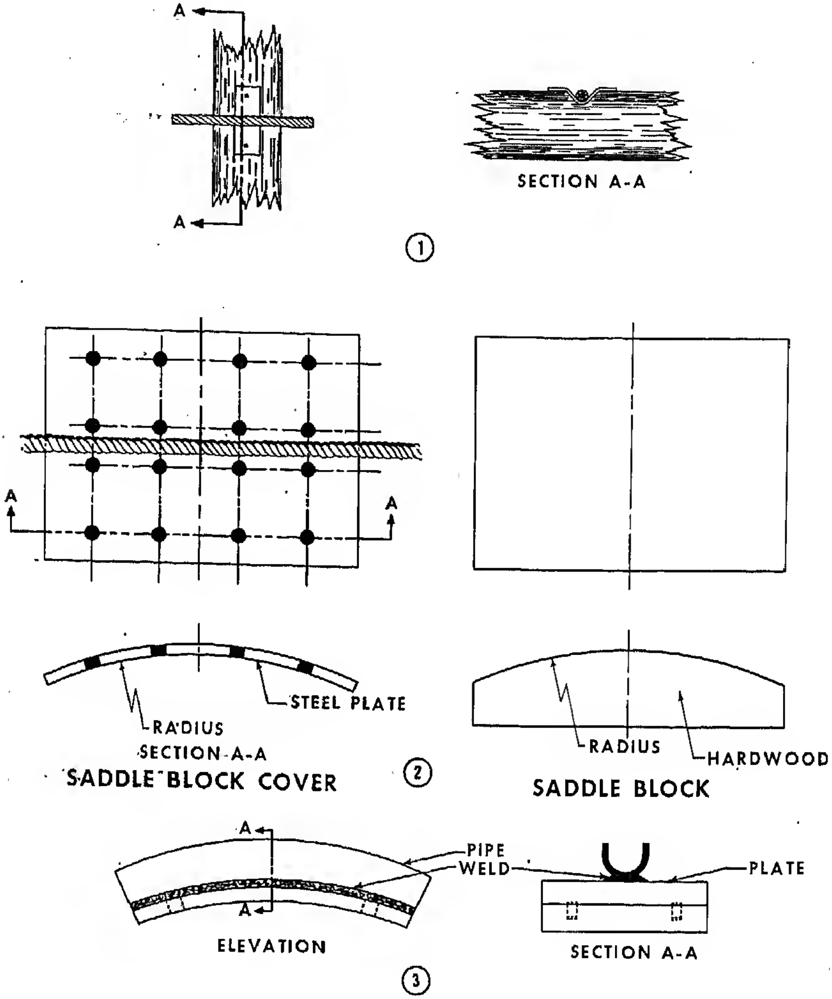


Figure 20. Expedient saddles.

used (fig. 21) if there is a higher overhanging limb. The limb does not need to be directly over the final position as tag lines can be used to pull the crossmember a short distance over into place. Bridge towers usually are completely assembled except for footings before erection. They are then raised into position and braced or guyed. Some instances will arise when a tower to be erected is too high or too heavy for normal methods, or where the vertical members are too long for erection by lifting them into place. Shears can be rigged (fig. 22) to handle many such cases. If shears would be inadequate, a gin pole (fig. 23) can be used.

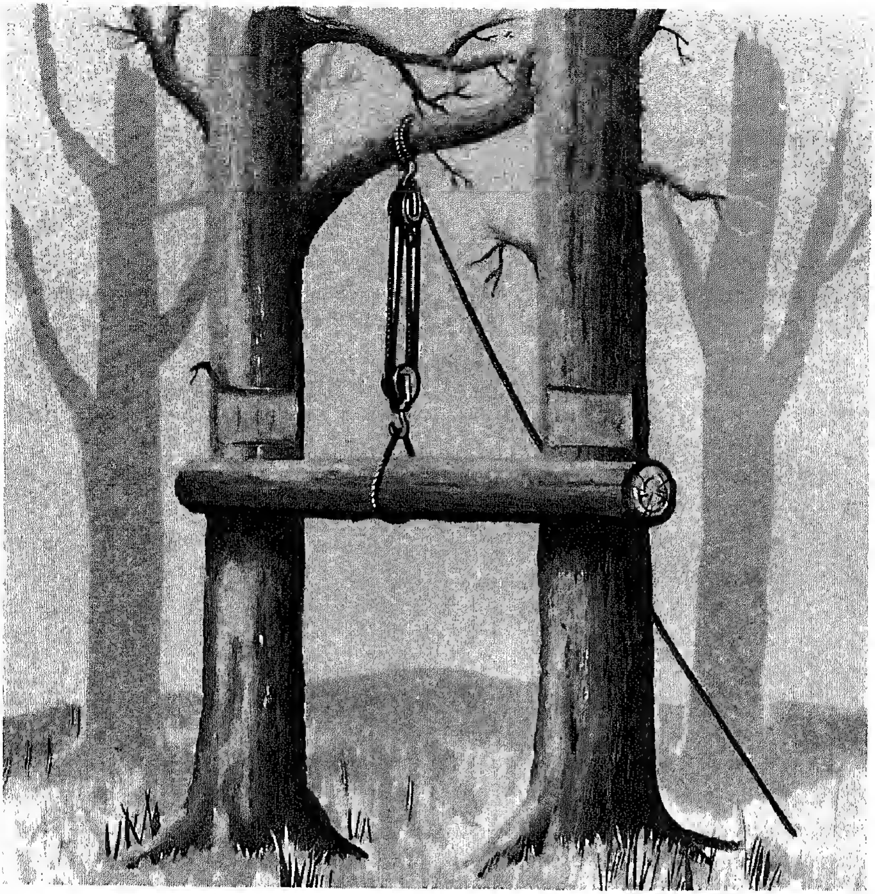


Figure 21. Use of tackle to erect tower.

Section II. CABLEWAY AND TRAMWAY TOWERS

25. Post-Type Tower

In figure 24 a typical lower terminal installation is shown, using a post-type tower for track cable support. Make the vertical members of this type of installation out of timber not less than 8 inches in diameter and long enough so that 18 inches or more can be set into the ground. Dig two holes for the uprights approximately 6 feet apart in a manner that will disturb the earth as little as possible. Cut the tops of the uprights to fit the crossmember as nearly as possible. If half-round cuts cannot be made, saw in at an angle from each side to provide a notch for the crossmember. Set the uprights so the cross-member will be horizontal and fill the holes around the bases with earth tamped securely. Cut a crossmember from timber 8 inches or more in diameter and long enough to span the uprights and extend

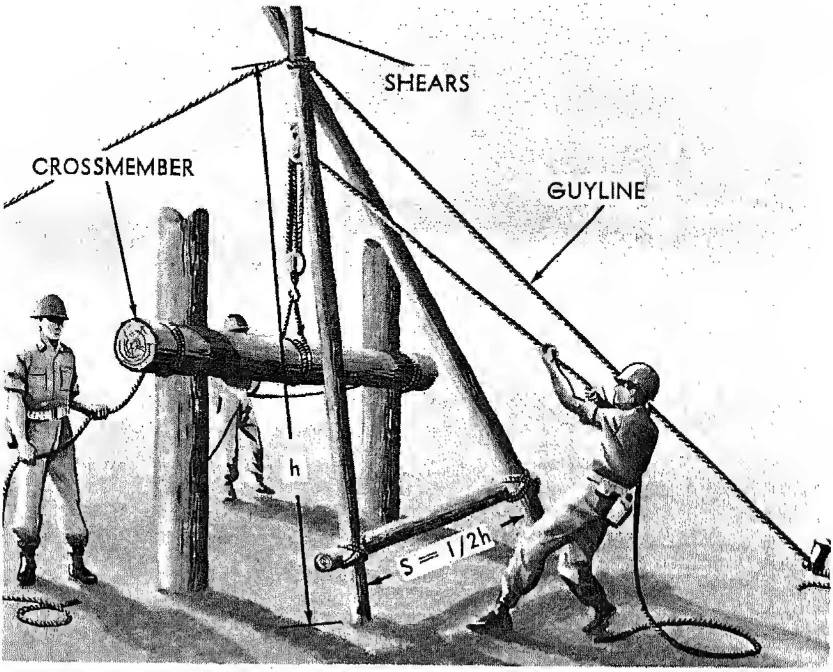


Figure 22. Use of shears to erect tower.

about 1 foot beyond each upright at the ends. Fasten two wire rope guylines to each end of the crossmember with at least two turns around the crossmember and wire rope clips to hold the ends. A single piece of wire rope can be used for the two guylines at each end by wrapping two or three turns about the crossmember in the center of the wire rope and attaching the ends to the anchorages. Hoist the crossmember into place on the uprights before anchoring the guylines. When the crossmember is in place, drive anchor stakes for the guylines partly into the ground. Take two turns in each guyline about its anchor stake and fasten the ends with wire rope clips. After attaching the guylines, drive each of the four anchor stakes an additional amount as necessary to tighten four guylines equally. Guylines can also be anchored to standing trees where desirable. If the installation is on rocky ground, rock anchors (para. 38) can be used. A braced post tower (fig. 25) is a more stable arrangement, because the posts are angled both ways to increase stability.

26. Standing Tree Tower

Where standing trees are so located that there is an area in front of them suitable for unloading space and an area back of them for anchorage and power unit placement, they can be used instead of a

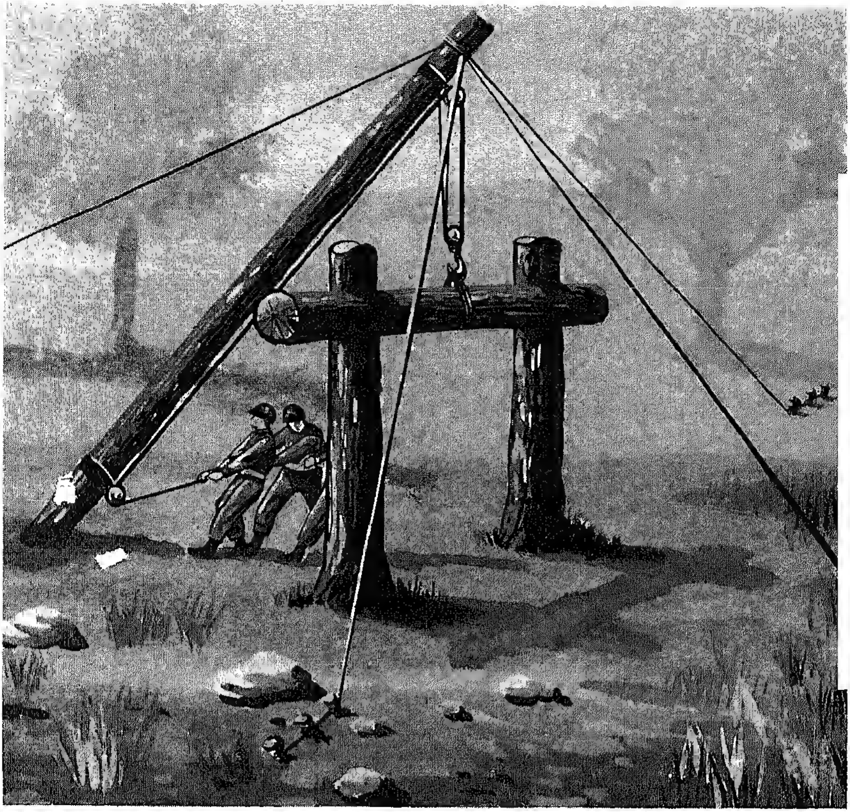


Figure 23. Use of gin pole to erect tower.

tower (fig. 26) and provide a simpler construction. The line between the two trees need not be at a right angle to the line of the track cable although this is preferred. Trim off limbs and branches which might interfere with operations. Cut a timber crossmember. The crossmember must be long enough to span the distance between the trees and project about a foot beyond each tree. If the trees are 8 feet or less apart, the crossmember should be at least 8 inches in diameter. For trees 8 to 12 feet apart, the crossmember should be at least 10 to 12 inches in diameter. The crossmember must be placed at a height sufficient to provide clearance for the carrier. Mortise the standing trees (fig. 27) and the crossmember to provide a shoulder and hoist the crossmember into place. Lash the crossmember securely to both trees to hold the mortised joints tight. Use ½-inch diameter wire rope for lashing and fasten the ends of the lashing with wire rope clips. Guylines are not usually required for this type of tower.

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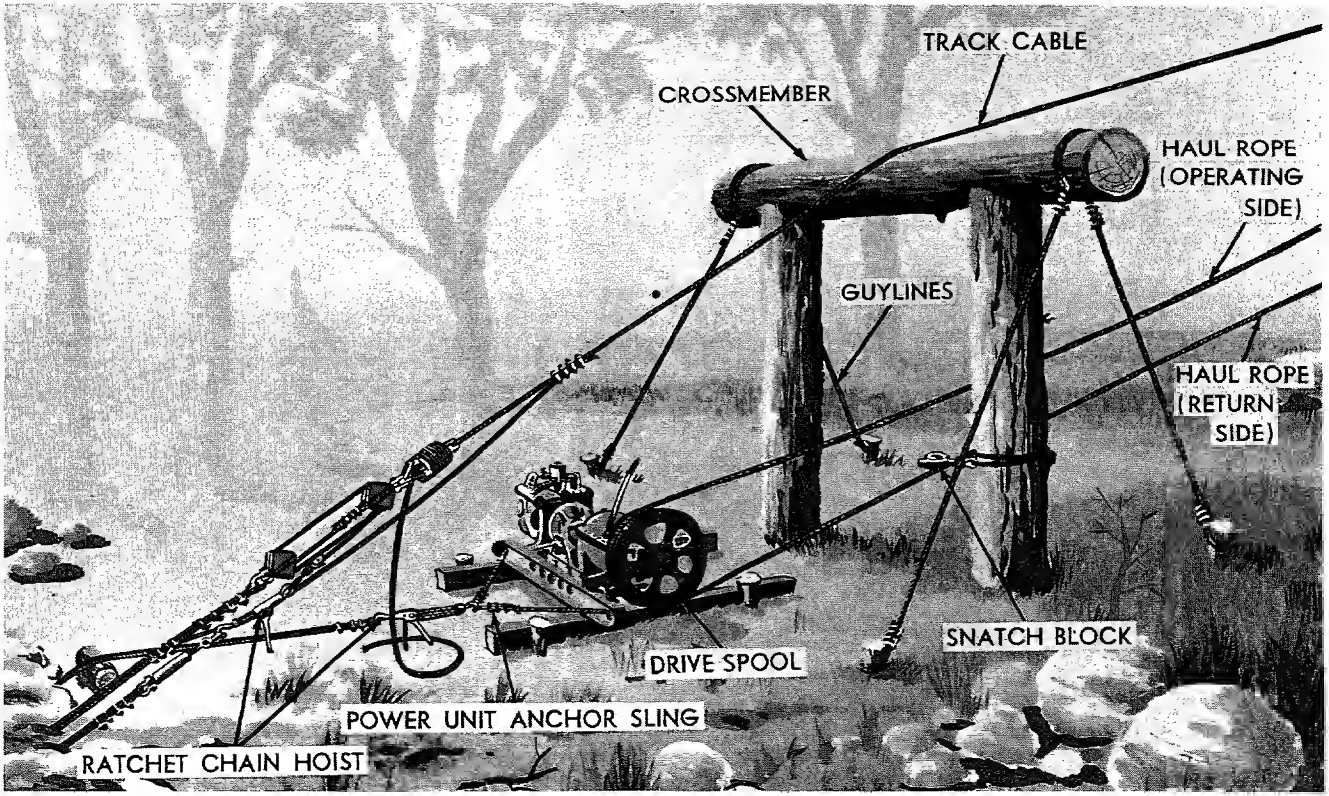


Figure 24. Lower terminal installation.

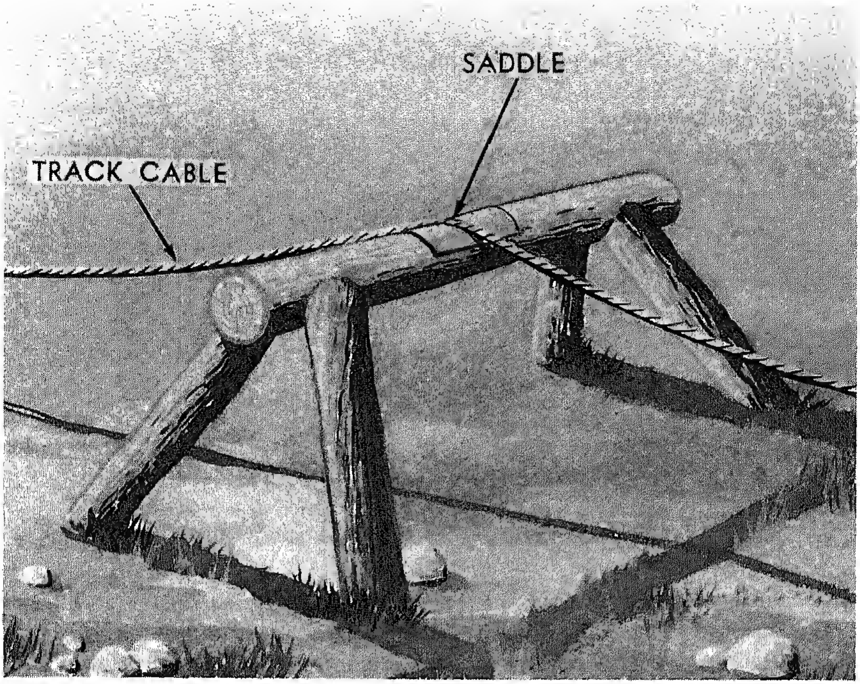


Figure 25. Braced post tower.

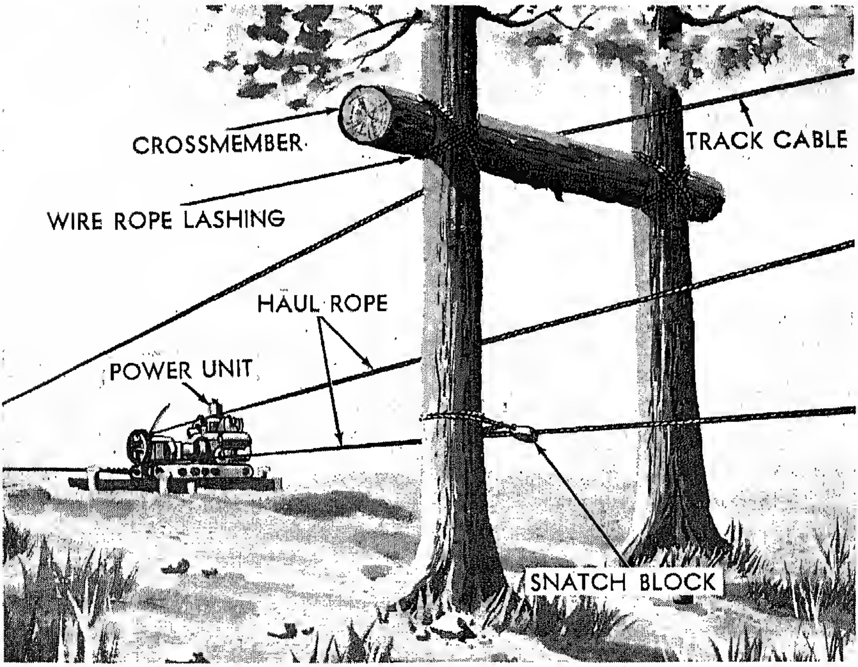


Figure 26. Tower made from standing trees.

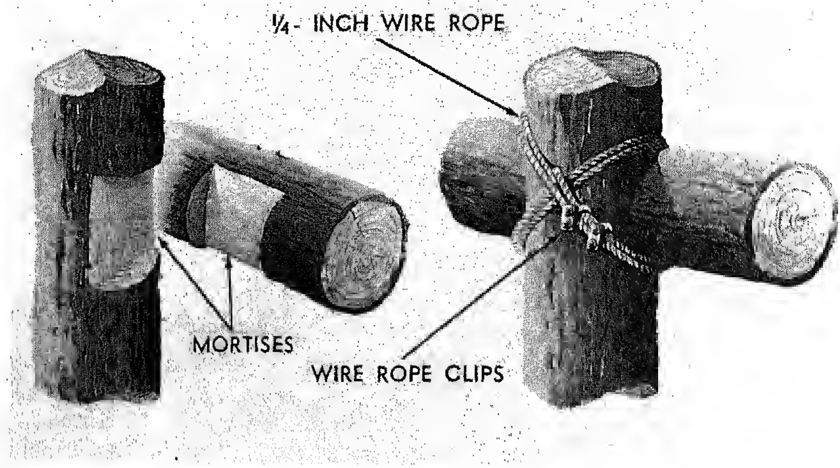


Figure 27. Mortised joint for crossmember support.

27. Two Standing Trees—Intermediate Tower

When two standing trees at least 8 inches in diameter and of suitable height are spaced a sufficient distance apart to provide carrier clearance, they can be used for an intermediate tower. A timber crossmember or wire rope can be used to support the track cable hanger.

a. Timber Crossmember. When a timber crossmember is used between two standing trees for an intermediate tower, it is prepared and installed in the same manner as outlined in paragraph 26. Such towers usually will not require guylines unless the crossmember is placed more than 10 feet above the ground. After the crossmember is lashed in place, the track cable hanger is lashed to the crossmember with wire rope. Take two turns around the crossmember with a piece of ½-inch diameter wire rope and fasten the end to the standing part with wire rope clips. Pass the wire rope under one hook, around the back of the grooved portion (fig. 28), and under the other hook on the hanger plate of a track cable hanger. Take two turns around the crossmember with the free end of the wire rope and fasten it to the standing part with wire rope clips.

b. Wire Rope Suspension. The track cable hanger can be suspended between two standing trees by a wire rope. Guylines must be placed on the trees to prevent them from bending inward when a loaded carrier passes. A stabilizing wire between the guylines above the suspension wire will contribute to the rigidity of the structure. Use ¼-inch diameter wire rope for the stabilizing wire and guylines. Use ½-inch diameter wire rope to suspend the track cable hanger. Take two turns in one end about one tree and fasten the free end to

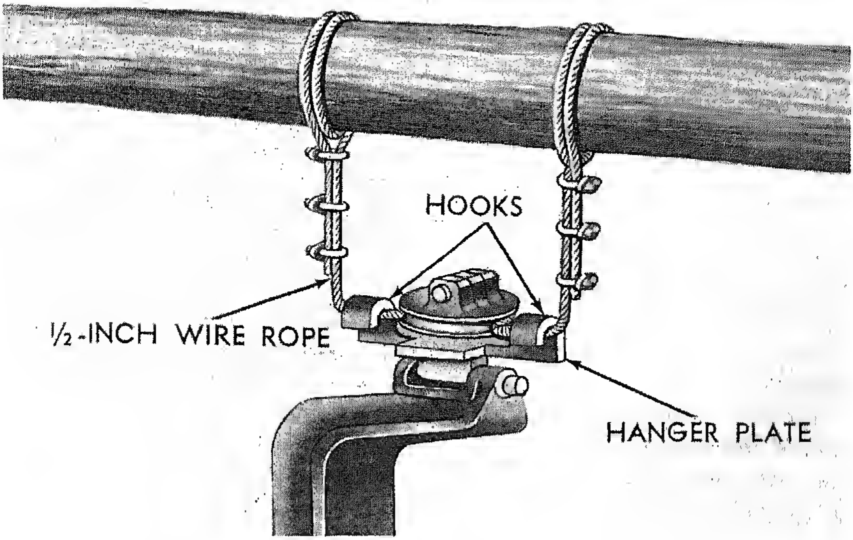


Figure 28. Attaching track cable hanger to timber crossmember.

the standing part with three wire rope clips. Pass the wire rope under one hook, around the back of the grooved portion (fig. 28), and under the other hook on the hanger plate of a track cable hanger. Be sure the track cable hanger is placed on the suspension wire so it will hang in the center or in a position to provide carrier clearance. Pass the free end of the suspension wire around the second tree, pull it snug, and take two turns about the tree. Fasten the free end to the standing part with three wire rope clips.

28. One Standing Tree—Intermediate Tower

A single standing tree can be used for a tower by felling another tree to lean against the first tree, or a crossarm can be attached.

a. Felling Second Tree. This method is generally of use where two trees are located too far apart for use of a timber crossmember but close enough together to fell one into another. Trim any limbs or branches which might interfere with lashing the trees together off both trees. Loop a rope around the tree to be felled and place several men on each end of it. Start cutting the tree and as it weakens pull it toward the uncut tree (fig. 29). Use poles to help direct its fall. When the cut tree is located against the uncut tree, place the butt of it against a stump or in a hole to prevent movement of the butt. Lash the two trees together securely, using ¼-inch wire rope. A timber crossmember (fig. 26) can now be placed across the two trees as in paragraph 26 and used to support the track cable hanger (para. 27*a*). If the felled tree leans at an angle sufficient to provide carrier clearance, the track cable hanger can be lashed directly to the leaning

tree in the same manner as it would be attached to a timber cross-member. The high side of the supporting wire must be longer so the track cable hanger will hang vertically. Wire rope suspension for the track cable hanger can be used (para. 27*b*), but the timber cross-member is preferred. Guylines are not usually required for rigidity in wire rope suspension because of the natural rigidity of such a triangular structure.

b. With Crossarm. Make the crossarm from a timber at least 8 inches in diameter and long enough to support the track cable hanger (fig. 30) at a point which will provide carrier clearance. Mortise the joint (para. 26) and lash the crossarm to the tree with ¼-inch diameter wire rope. Take two turns in the end of a ½-inch diameter wire rope about the crossarm at a point which will be directly above the track cable hanger in the final installation. Fasten the free end of the wire rope to the standing part with wire rope clips. Put this supporting wire rope about the trunk of the standing tree at a point which will cause the rope to make an angle of not less than 45° with the crossarm. A 60° angle is preferred. Take up on the supporting wire rope until the crossarm is horizontal and the wire rope is tight. Take two turns of wire rope about the tree trunk and fasten the free end to the standing part with wire rope clips. If

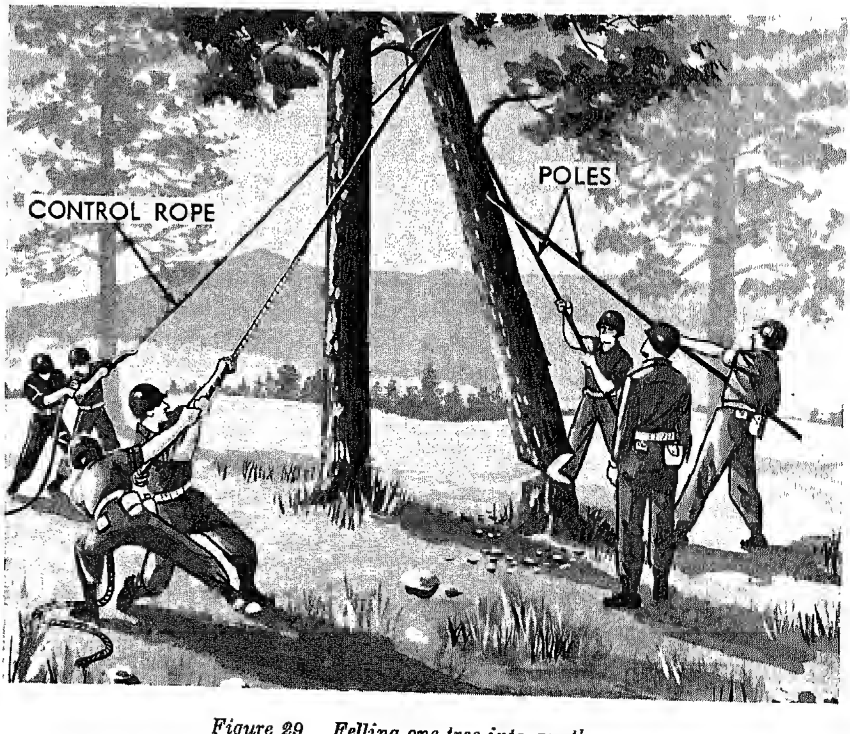
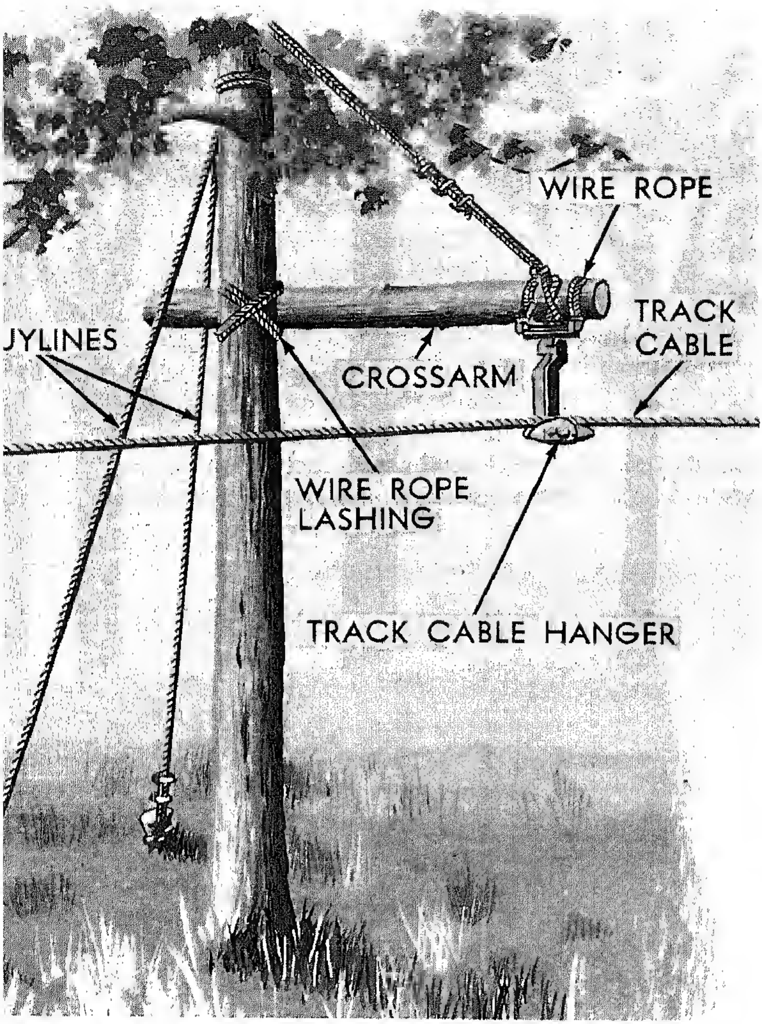


Figure 29. Felling one tree into another.



30. Intermediate tower using one standing tree with crossarm.

ling tree is 8 inches but less than 10 inches in diameter, guyline around the tree at the point where the crossarm g wire is fastened. Anchor the guyline so that it forms an h the ground of at least 45°. The guyline can be made of ameter wire rope. Lash the track cable hanger to the cross- e manner outlined in paragraph 27*a*.

ame Tower

rame intermediate tower is best suited for locations where low towers are required. Cut the side members of the A- m timbers at least 8 inches in diameter and long enough to

allow for setting 18 inches in the ground. Allowance must also be made for the top joint so that the finished A-frame (fig. 31) will have adequate clearance both vertically and horizontally for a carrier to pass. In determining clearance be sure to allow for possible swinging of the carrier and for loads which might project beyond the sides. Mortise the side members (fig. 27) at an angle for the upper joint at least 10 inches from their ends and lash the two of them together with ¼-inch diameter wire rope. Fasten the ends of the lashing with wire rope clips. Dig holes in the ground 18 inches deep and set the lower ends of the side members in them. Support the A-frame temporarily in a vertical position, fill the holes with loose earth, and tamp it firmly into place. Attach four ¼-inch diameter wire rope guylines to the A-frame and anchor them firmly. Lash an 8-inch diameter crossmember (fig. 31) securely to the side members. For installations where the side members cannot be set into holes in the ground, the crossmember should be mortised and lashed in place

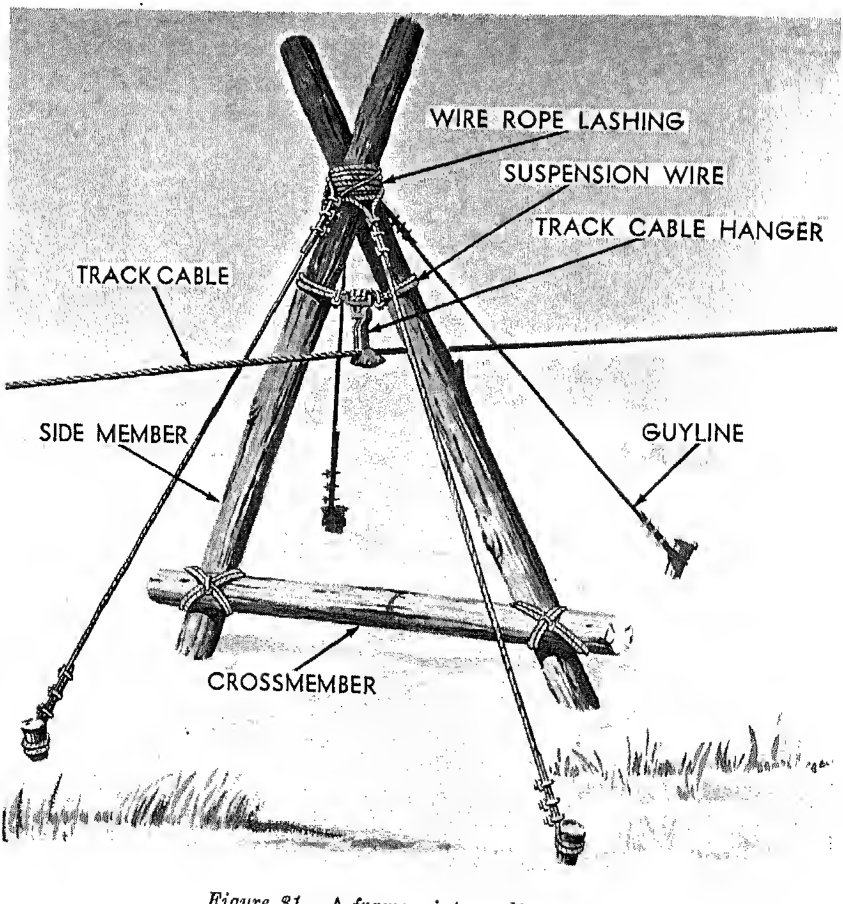


Figure 31. A-frame—intermediate tower.

before the A-frame is erected. Suspend the track cable hanger with a wire rope fastened between the side members as outlined in paragraph 27*b*.

Section III. BRIDGE TOWERS

30. Tower Location

In some cases, standing tree or post-type towers may be used f suspension bridges, but generally because of the proximity to the ga they will not be practical. The situation would have to be exa where the roadway could run between the trees. Also suitable are for placing posts without a sill or footing adjacent to a gap are n common; therefore, suspension bridge towers call for different co struction. The span of the bridge and the sag in the cable will d termine the tower height. For short bridges with light loads, towe are not required. Towers are constructed from native timbers dimension lumber, depending upon availability.

31. Short Span Tower

A tower which can be used for spans less than 140 feet is shown figure 32. The cables are supported on short saddle posts attach by driftpins to the outside of the main post of the tower. The cro brace must be high enough to allow overhead clearance of the e pected type of traffic. The tower is constructed of 12-inch logs.

32. Timber Towers

Figure 33 shows two examples of bridge towers constructed from native timbers. The tower in (①, fig. 33) is used when some dimension lumber is available for use as bracing. If dimension lumber is limited, a tower similar to the one in (②, fig. 33) may be constructed.

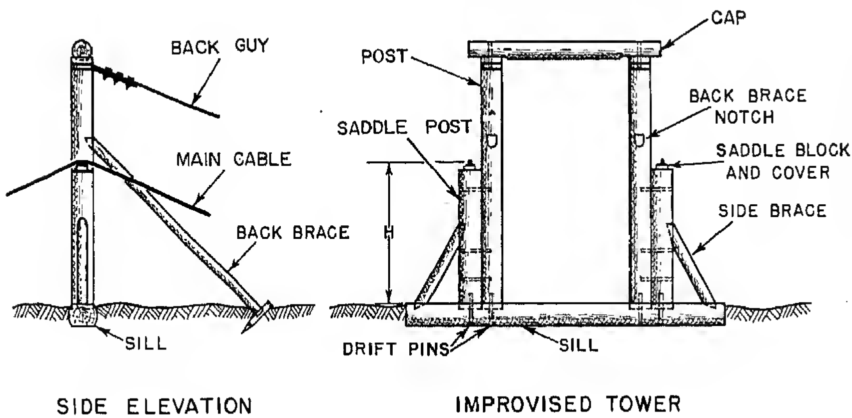


Figure 32. Improvised tower for short spans.

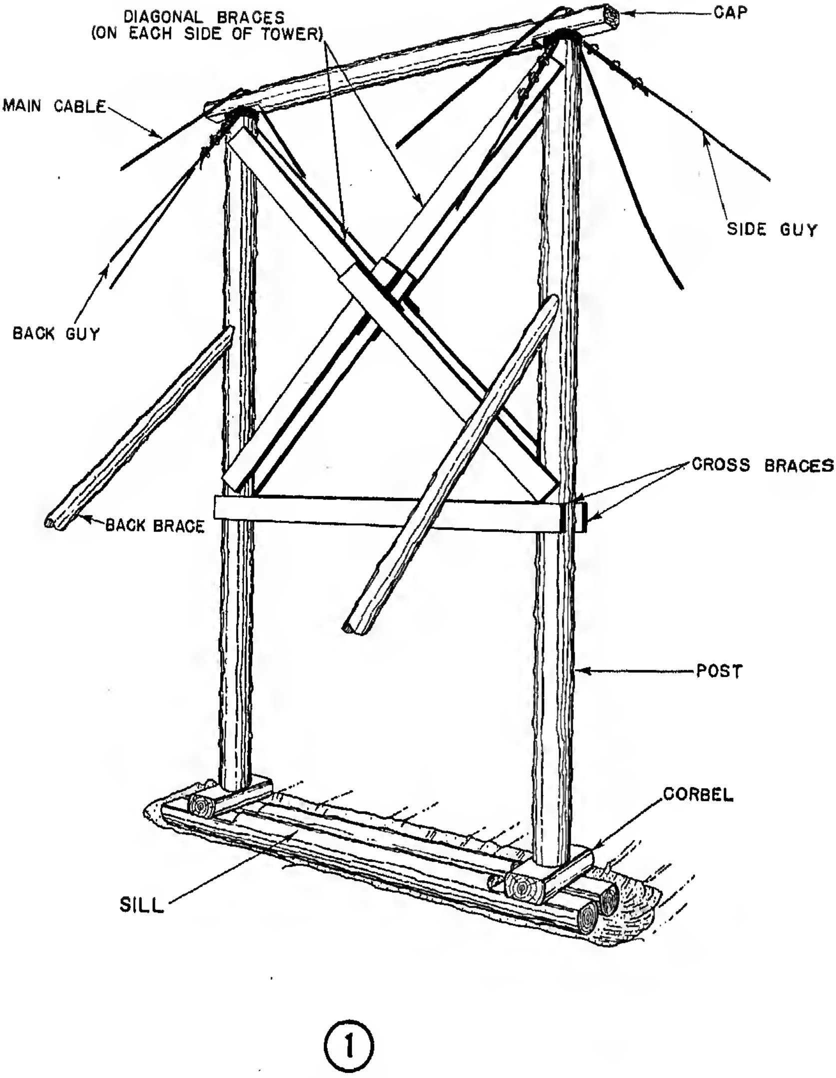


Figure 33. Improvised towers for suspension bridges.

The posts and sills are 12-inch logs with 10-inch log caps and 6-inch log braces. These towers can be used for spans up to 300 feet and loads to 4,000 pounds. The height of the tower depends upon the sag and span of the bridge, and the width depends upon the clearance desired.

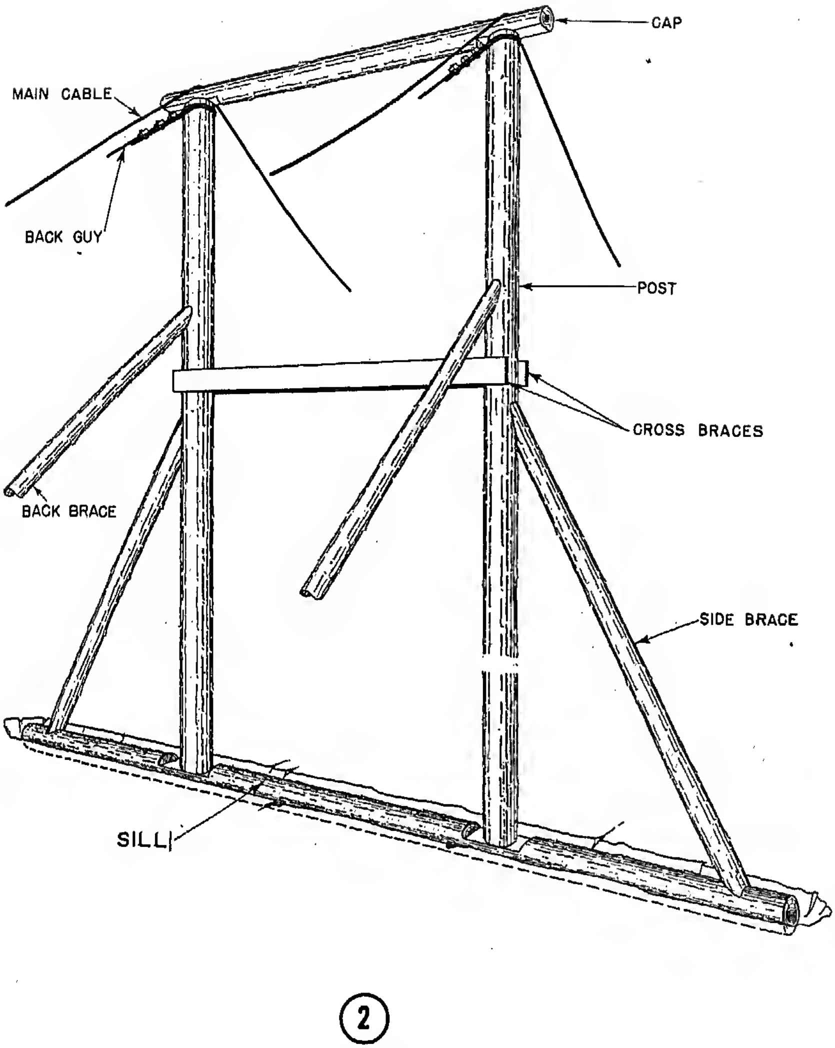


Figure 33.—Continued.

33. Prefabricated Tower

An example of a tower constructed from 2- by 10-inch lumber, 10 feet long is shown in figure 34. The sill is a builtup lap-jointed piece 4 inches thick. The posts are 8- by 10-inch builtup lap-jointed and are nailed to the sill. The sides of the sill, cap, and braces are all 2- by 10-inch lumber. Saddle blocks are placed on the posts to support the main cables. The height and width depend on the sag and span of the bridge and the necessary clearance for the design load.

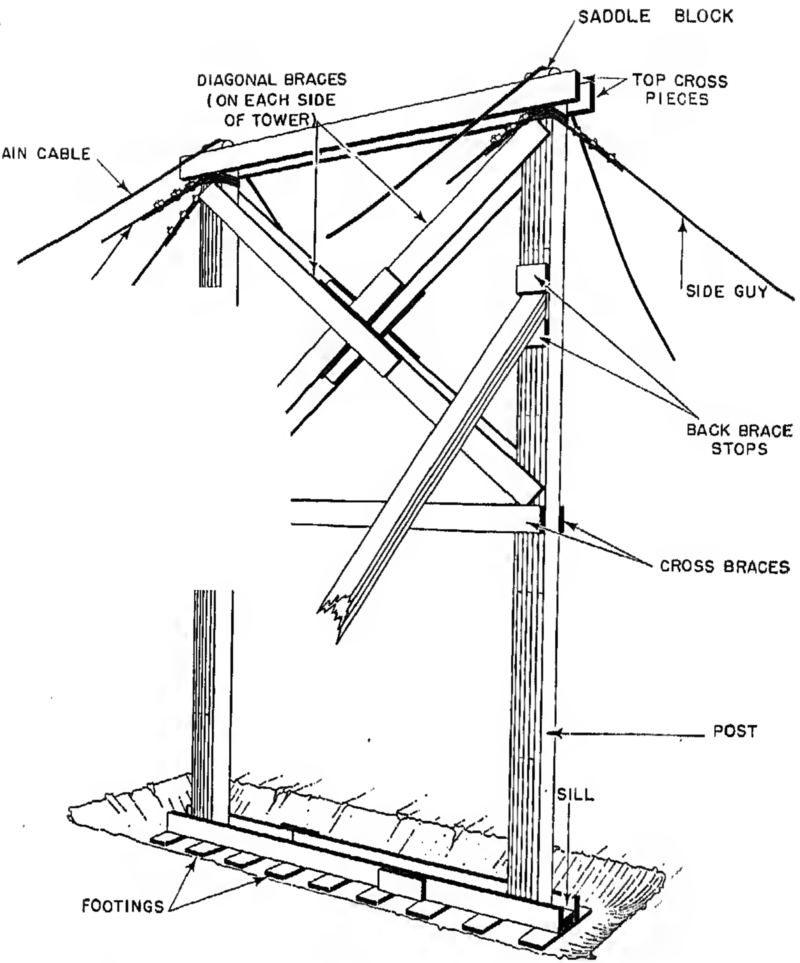


Figure 34. Tower constructed from dimension lumber.

Section IV. ANCHORAGES

34. Purpose and Use

Wherever possible in cableway and tramway installations, natural anchorages should be used for speed and economy of rigging. Other temporary anchorages which may be used include pickets, rock anchors, holdfasts, and deadmen. Permanent anchorages may be made up of steel anchors set in concrete or fastened to permanent structures. Guylines should always be fastened to anchorages at a point as near to the ground as possible. Also, the guyline should leave the anchorage as nearly parallel to the ground as possible, except in the case of rock anchors. The wedging action of a rock anchor is such that it is strongest under a direct pull and it should be set with this in mind.

35. Natural Anchors

Trees, stumps, or rocks can be made to serve as natural anchorages for rapid work in the field. Avoid using a rotten tree or stump or a dead tree as an anchorage, because such anchorages are likely to snap suddenly when a strain is placed on the guyline. It is always advisable to lash the first tree or stump to a second one, to provide added support. A transom (fig. 35) can be placed between two trees to provide stronger anchorage than a single tree. When using rocks (fig. 36) as natural anchorages, examine the rocks carefully

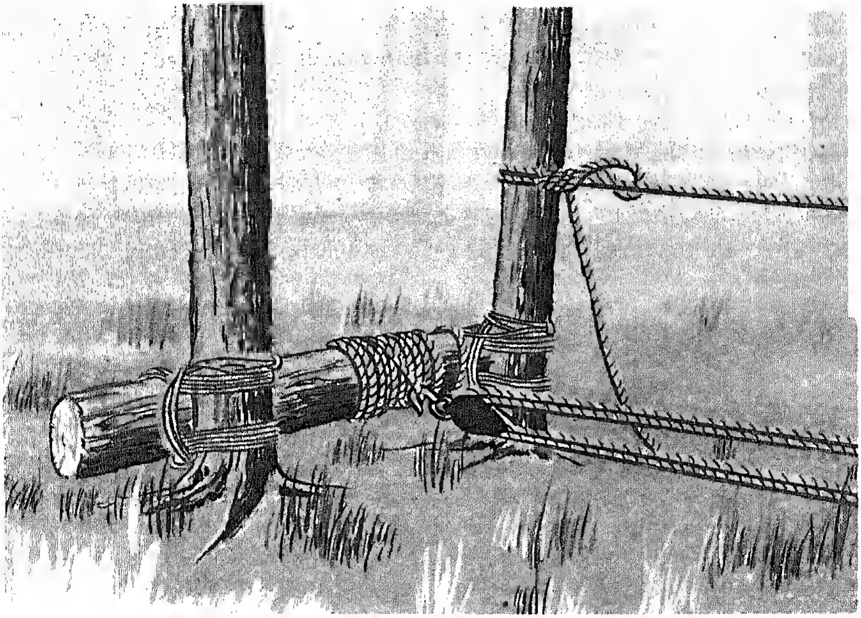


Figure 35. Use of trees and transom as natural anchorage.

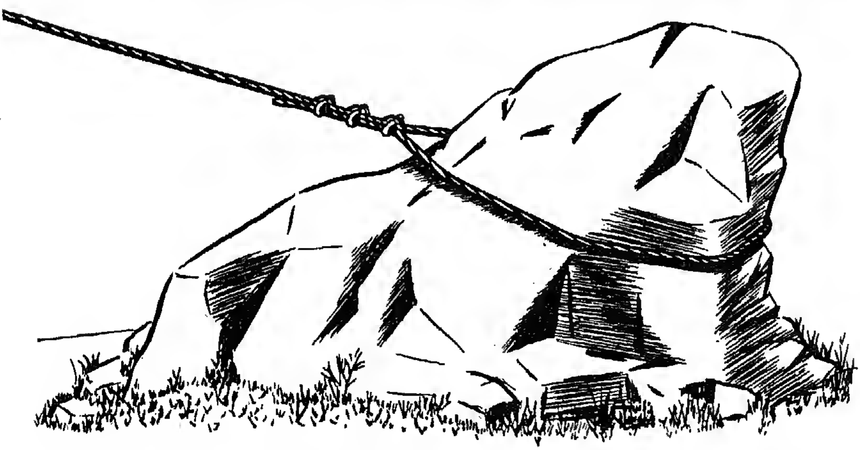
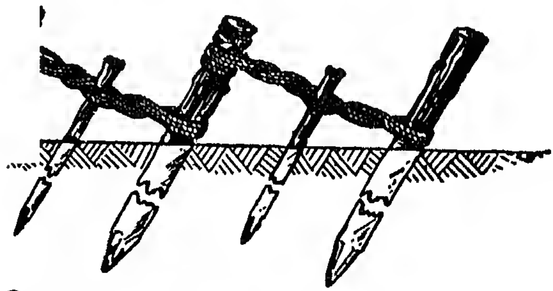


Figure 36. Using a rock for natural anchorage.

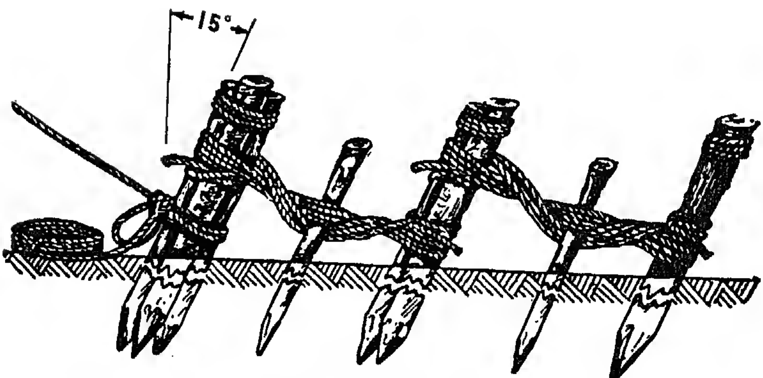
to be sure that they are large and firmly embedded in the ground. ·ng of rock or a heavy boulder lying on the ground will sfactory anchorage.

ɔle Pickets

·· in the strength of a picket holdfast is the holding power l The strength of the holdfast can therefore be in- the surface area of the pickets against the pickets driven into the ground and lashed ·····er holdfast than a single picket. To ɜt, drive round pickets at least 3 inches ɒout 3 feet into the ground, spaced 3 to ;uyline (①, fig. 37). Pickets should be l opposite the direction of pull. Tie ·ith a clove hitch and take from four to



① PICKET HOLDFAST



② 3-2-1 COMBINATION PICKET HOLDFAST

Figure 37. Multiple picket holdfast.

around the first and second pickets, from the bottom of the icket to the top of the first picket. Then fasten the rope to nd picket with a clove hitch just above the turns. Pass a tween the rope turns and tighten the rope by twisting the d driving it into the ground. Place a similar lashing between nd and third pickets. If wire rope is used for the lashing, complete turns are necessary around each pair of pickets. r fiber rope nor wire rope is available for lashing, boards placed from the top of the front picket to the bottom of the icket and nailed firmly at each picket. The principal part rength of a multiple picket holdfast is the strength of the front, picket. To increase the surface area of this first gainst the ground, three or four pickets can be driven into nd close together. Lash these pickets (②, fig. 37) to a icket group, and lash it to a third picket group. Good ash installed as outlined above, should stand the following pulls urbed loamy soils:

picket	700 lb
icket holdfast combination	1,400 lb
picket holdfast combination	1,800 lb
icket holdfast combination	2,000 lb
picket holdfast combination	4,000 lb

nbination Holdfast

avy loading of an anchorage, it is desirable to spread the r the largest possible area of ground. This can be accom- y increasing the number of pickets used. Four or five multi- t holdfasts (para. 36) can be made up parallel to each other avy log resting against the front pickets to form a combina- picket holdfast (fig. 38). The guyline or anchor sling is to the log which bears against the pickets. The log should ly against all pickets in order to obtain maximum strength. gth of the log used will affect the strength of the combination as the strength of the individual holdfasts. The timber e carefully selected to stand the maximum pull on the line appreciable bending. The same function can be performed steel crossmember, forming a combination steel picket hold- 39).

k Anchors

anchors are supplied with some of the issue sets discussed nanual. The rock anchor (fig. 40) has an eye on one end. r end is threaded and has a nut, an expanding wedge, and a on it. Insert the threaded end of the rock anchor in the hole nut clear of the wedge. After the anchor is placed, insert ar through the eye of the rock anchor and twist it. This

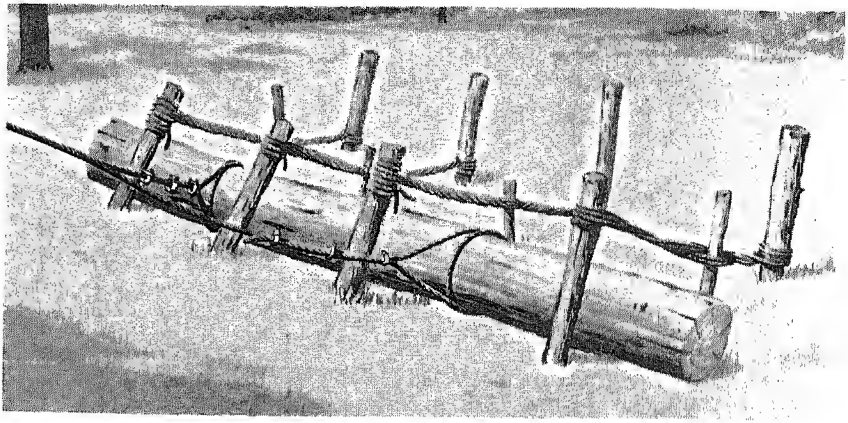


Figure 38. Combination log picket holdfast.

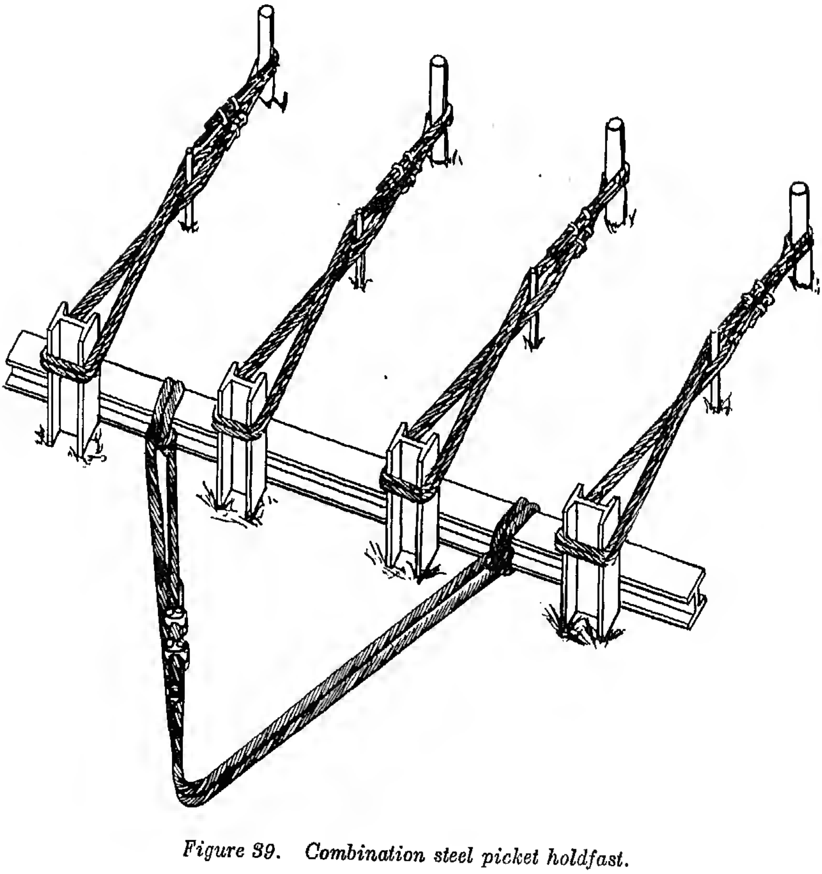


Figure 39. Combination steel picket holdfast.

causes the threads to draw the nut up against the wedge, forcing the wedge out against the sides of the hole in the rock. The wedging action is strongest under a direct pull, and rock anchors should always be set so that the pull is in a direct line with the shaft of the anchor. Holes for rock anchors should be drilled 5 inches deep. In hard rock use a 1-inch diameter drill. In soft rock use a ¾-inch diameter drill and drill the hole as neatly as possible in order for the rock anchor to develop maximum strength. It is better to use some other type of anchor in extremely soft rock as the wedging action may not give sufficient holding power.

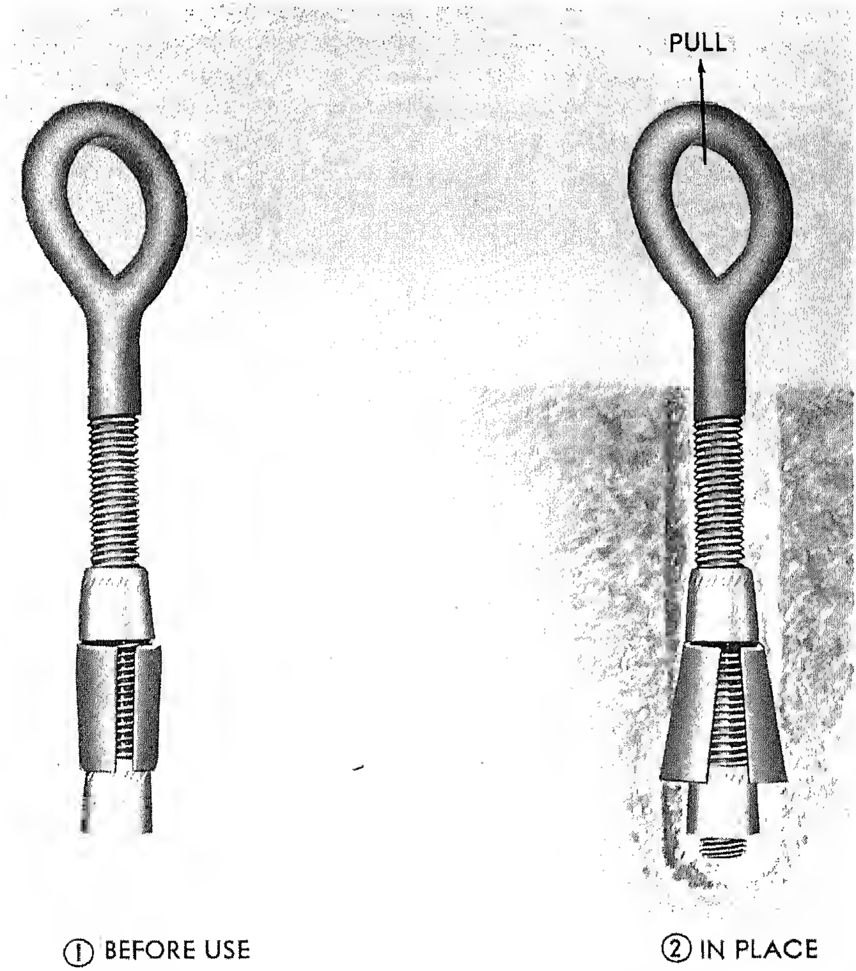


Figure 40. Rock anchor.

39. Deadmen

a. Features. A deadman provides greater strength than a holdfast under most conditions. It is more suitable for permanent installation, since it is buried, and is the best form of anchorage for heavy loads because of the large surface area presented against undisturbed soil. A deadman consists of a log (fig. 41) buried in the ground with the guyline or anchor sling connected to it at its center. In some installations, arrangements may be necessary to slacken or tighten the guylines, such as putting in a turnbuckle near the ground or installing the takeup tackle. For more detailed information consult TM 5-725.

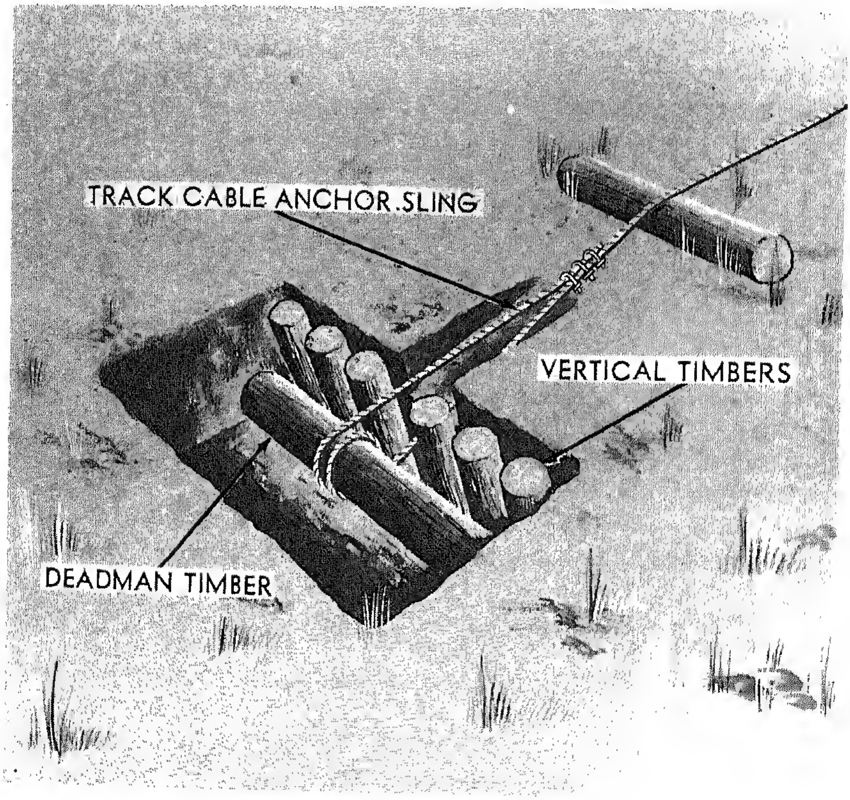


Figure 41. Features of a log deadman.

b. Installation.

(1) The hole in which the deadman is buried should be as deep as is necessary for good bearing on solid ground. To use as much of the surface of the undisturbed earth as possible, undercut the bank in the direction toward the guyline at an angle of about 15° from the vertical.

(2) Drive stakes into the bank at several points over the deadman to increase bearing surface.

(3) Cut a narrow inclined trench for the guyline or anchor sling through the bank, leading to the center of the deadman. It is advisable to place a short beam or log on the surface of the ground under the guyline or anchor sling at the outlet of the inclined trench.

(4) Fasten the guyline or anchor sling securely to the center of the deadman so that the standing part of the line, on which the pull occurs, will lead from the bottom of the deadman. This reduces the tendency of the deadman to rotate upward out of the hole. Clip the running end of the guyline securely to the standing part.

(5) The strength of the deadman depends partly on the strength of the log which is buried, but mainly on the holding power of the earth. The holding power of deadmen in earth is given in table XIX in appendix II.

CHAPTER 4

EXPEDIENT CABLEWAYS

Section I. DESIGN

; a cable for a cableway, certain conditions must be
to be transported, the span, and the maximum
The span and allowable deflection may be
profile as discussed in paragraph 9. From the
leflection, the possible sag in the cable may be
ing a cable, a cable size must first be assumed,
performed. If the results are unsatisfactory,
e size is assumed and the calculations again performed.

Cable Selection by Formula

a. To select a cable size, formulas 7, 8, and 9 (para. 19*b*) are used.

Example:

A 1,000-pound payload is to be transported across a 500-foot gap. The maximum allowable deflection is 25 feet at the center. In order to use the formulas, a cable size and type must be assumed. From table XVIII, appendix II, select a 6 x 19½-inch diameter improved plow steel (IPS) wire rope. The breaking strength is 10.8 tons and the weight per foot is .40 pounds. Since a payload of 1,000 pounds is desired, a carrier and haul rope weight must be included in the P. In this example, assume 100 pounds. Then P=1,100 pounds. To find horizontal tension, apply formula 7:

$$t=\frac{500[2(1100)+.4(500)]}{8(25)}=\frac{500[2200+200]}{200}$$

$$t=6{,}000 \text{ pounds}$$

To find β_1, apply formula 9:

$$\text{Tan } \beta_1=\frac{P+ws}{2t}=\frac{1100+200}{2(6000)}=.108$$

$$\beta_1=6°10'$$

To find cable tension, apply formula 8:

$$t'=t \sec B_1$$

$$=(6000)\ (1.006)$$

$$t'=6{,}050 \text{ pounds}$$

The allowable tension in the cable is the breaking strength divided by the safety factor or—

$$t \text{ allowable} = \frac{BS}{3.5} = \frac{10.8(2000)}{3.5} = 6{,}200 \text{ pounds}$$

The ½-inch cable is within the allowable tension and therefore can be used. If the allowable tension was less than the tension in the cable, a larger size would be assumed and the computations redone. If the allowable tension was considerably greater, then a smaller size could be assumed.

b. A simplified formula which can be used to determine the safe load on a cable where the sag is 5 percent is—

$$SL = \frac{BS}{5(SF)} - \frac{DL}{2}$$

Where:

BS = Breaking strength of cable
SF = Safety factor
DL = Dead load on weight of the cable per foot times the span
SL = Safe load

The weight of the carrier and haul rope must be subtracted from the safe load to determine the payload.

42. Field Design of Cable With Graphs

To facilitate cable selection using the graphic method, a profile of the centerline similar to figure 42 should be made. In order to determine the allowable sag, formula 10 (para. 19*c*) is used.

Example:

A payload of 2,000 pounds is to be transported over the 1,000-foot distance shown in figure 42. From the profile, the vertical difference in elevation between towers is 280−80=200 feet. The percent slope is expressed as $100\left(\frac{h}{s}\right)$ or $100\left(\frac{200}{1{,}000}\right)=20$ percent. The elevations most likely to give trouble with the clearance are B and D. Assuming a sag ratio of 5 percent, a tentative sketch of the cableway can be drawn (fig. 43). The deflection at the center (y_c) will be 0.05 (1,000) = 50 feet. Using formula 10, the deflection at B is—

$$y = \frac{4(50)}{(1{,}000)^2}[1{,}000(200) - (200)^2]$$

$$y = 32 \text{ feet}$$

The distance from the horizontal to the chord at B is equal to $h\left(\frac{x}{s}\right)$ or $200\left(\frac{200}{1{,}000}\right)=40$ feet. Adding the two distances and subtracting the total from the elevation of 280 feet leaves 208 feet, which clears ground B by 98 feet. A similar check at D shows a clearance of 48 feet. Since this is more than is needed at either point, a greater sag can be allowed. Assume a 10-percent sag and recalculate. The

clearance at B is now found to be 9 feet. This is probably insufficient to clear the carriage, but since the towers will probably be at least 10 feet high, this will provide a total of 19 feet, which is sufficient. From appendix III, graph number 5 (fig. 153) covering a 10 percent sag and 20 percent slope, the vertical line for 1,000 feet span cuts the line for ⅝-inch cable at 3,050 pounds payload and the ½-inch cable line at 1,825 pounds payload. To use the intended 2,000 pounds payload, the ⅝-inch cable must be used, but the payload can be increased. If 1,825 pounds is sufficient payload, the ½-inch track cable can be used. The haul rope must be ⅜-inch wire rope in either case.

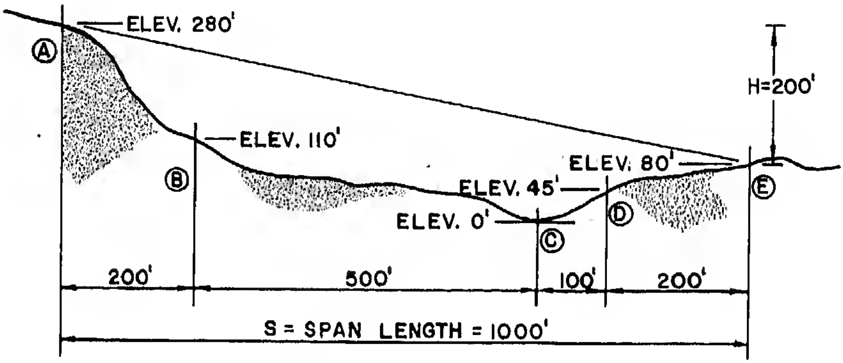


Figure 42. Field profile for example computation

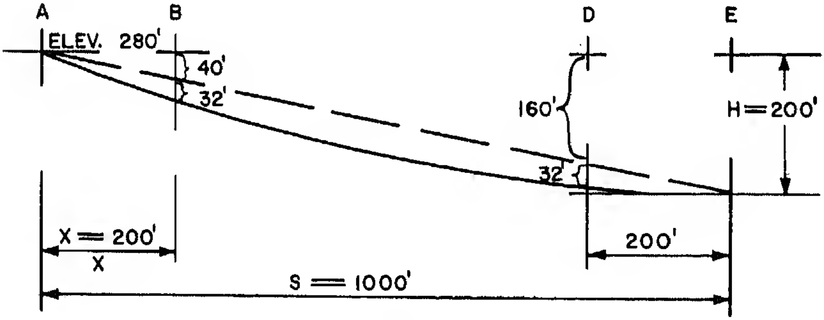
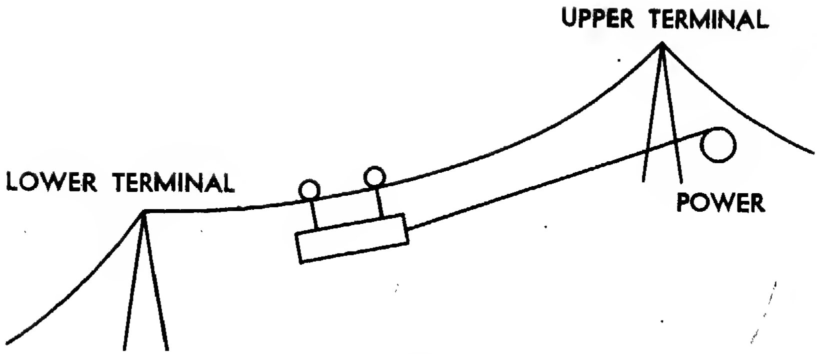


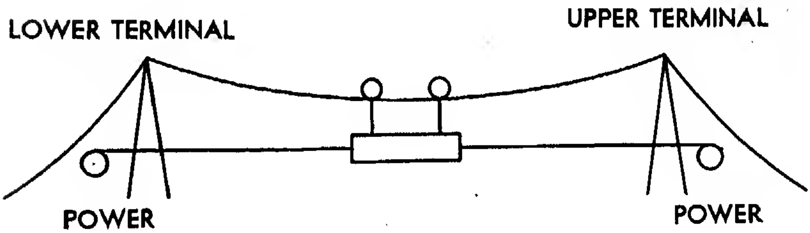
Figure 43. Tentative sketch of proposed cableway.

43. Haul Rope

There are three general methods of using a haul rope (fig. 44). In a skyline installation, the haul rope leads from the upper terminal to the carriage. The carriage is hauled up by the haul rope and allowed to move back down by gravity. If a second haul rope is added from the carriage to the lower terminal, the haul rope at one tower is paid out while the other end is used to pull the carriage. In the third



SKYLINE



HAUL ROPE AND TAG LINE

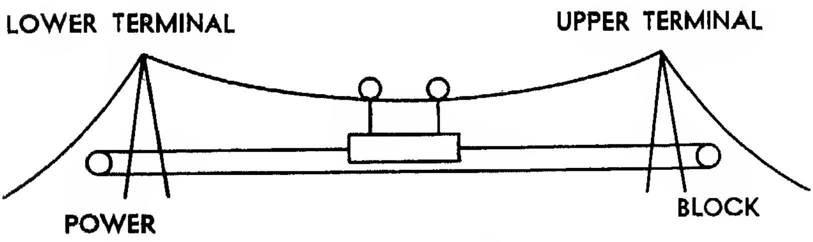


Figure 44. Diagram of haul rope arrangement.

method, a continuous haul rope is used. It leads from the upper
arriage around a snatch block at the upper tower and lower terminal, where it passes around the drive spool unit and back to the lower end of the carriage. When ınit is operated, the carriage is moved in the direction of

s. . The principal requirement for the carriage is that a means of supporting a load on sheaves to roll along For expedient construction, the payload for which igned will dictate the amount of simplification :ases, for light loads, a single snatch block may ıe towers are very high, the carriage will probably above the loading and unloading points. In such ıry to rig a tackle and fall line beneath the carriage ır the load at these positions. If the fall line is ıer terminal (fig. 45), leads to the carriage and over a fall block, and back up over a sheave on the ıwer source (hoist unit) at the lower terminal, it pro- ınd convenient method of hoisting and lowering loads. ıt the terminal is operated to raise or lower the load, vill remain in the same relative position beneath the carriage moves from terminal to terminal.

Heavy duty blocks and sheaves are included in the issue sets. For expedient cableways, heavy duty blocks may not be available. Numerous attempts to use standard construction blocks in expedient cableways have been unsuccessful. This is very heavy duty use which tends to wear the blocks excessively If the sheave is removed and reamed to permit insertion of a bushing of bearing bronze, most of the trouble will be eliminated. In any case, the blocks must be well lubricated. If no grease fitting is on the block,

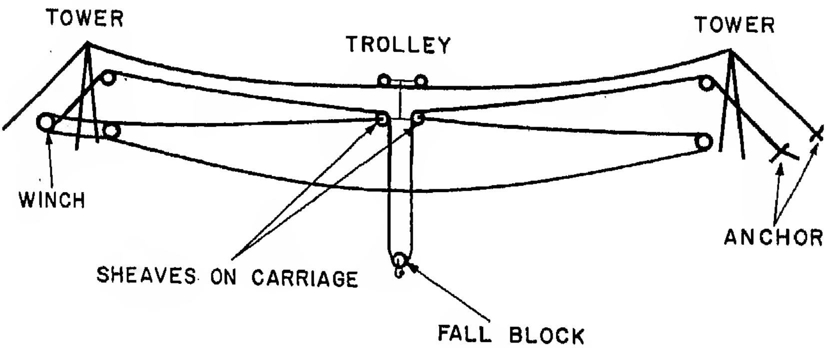


Figure 45. Diagram of hoisting arrangement.

install one. Grease such blocks with great frequency, even as much as once per trip of the cableway, if necessary to prevent cutting.

45. Power Unit

Power units are supplied with the issue sets, except for the casualty evacuation set, which usually employs gravity for power. Winches can be used for power sources. A power source can be improvised from truck components if no regular power source is available. The power trains from 6 x 6 and ¾-ton 4 x 4 trucks (fig. 46) have been used successfully. The motor, transmission, and transfer case can be assembled on a steel sled. In extreme cases, a vehicle can be blocked up and power taken off a rear wheel.

46. Towers

Tower height is determined from the field profile, after determining the type of installation and sag of the track cable. Towers are usually constructed at the site. They should be kept as low as possible to simplify design and construction. The principal con-

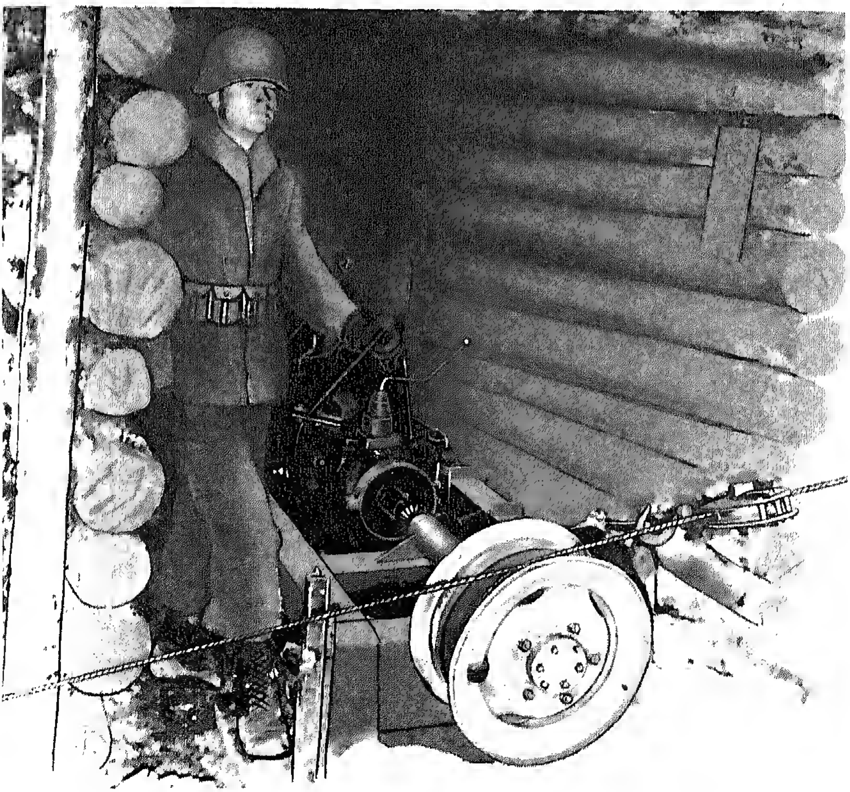


Figure 46. Improvised power unit in use.

sideration is the size of the timber required. The weight of the track cable and the weight of the imposed load combine to create a tension in the track cable. The track cable anchorage resists this, so the track cable on both sides of the tower has equal tension. The cable on both sides of the tower places horizontal and vertical loads on the tower depending on the angle of approach to the tower. The horizontal load is resisted by the guylines, placing an additional vertical load on the tower. The vertical reactions on the tower for varying sizes of track cable, sags, and slopes are shown in table XVII, appendix II. The maximum reaction for a 1¼-inch track cable is approximately 22,260 pounds. A 6- by 6-inch post will carry 18,000 pounds or two could carry the maximum load. For this reason it is recommended that expedient towers be made from standing trees 8 to 10 inches in diameter, or vertical posts 12 inches in diameter and well guyed. The size of the crossmember required depends partly on its length, but a timber 10 to 12 inches in diameter is sufficient if it does not span more than 6 feet. In smaller installations, the track cable can simply pass over the horizontal crossmember of the tower to the track cable anchorage. For long spans and heavy track cable, heavier crossmembers are required and a saddle such as described in paragraph 23 is needed to cover the timber. In some cases a sheave may be installed.

47. Guylines

Guylines are required at towers to take up the horizontal forces on the tower. For virtually any conditions, four ⅜-inch diameter wire rope guylines are sufficient to hold the tower in place provided their slope is 2 feet on the ground to 1 foot of vertical elevation. This means the anchorage for the guyline should be a distance from the base of the tower equal to twice the height. This provides a large margin of safety and allows considerable latitude in placing guylines at an angle to the direction of the track cable.

48. Anchorages

Any of the methods covered in chapter 3 which will provide sufficient holding power for the track cable or the guylines can be used. After the tension in the track cable has been determined, the holding power required for the anchorage will be the same and an appropriate type selected. A typical layout is shown in figure 7.

Section II. ERECTION

49. Rigging

Erection of a cableway consists mainly of the erection of the towers, track cable, and haul rope. There are endless variations in rigging guylines, installing anchorages, and rigging takeup gear. The cir-

cumstances at the site frequently require variation from fixed procedure on rigging. Takeup gear will usually consist of a tackle using two single or double blocks, depending on the mechanical advantage required. Refer to TM 5–725 for detailed information on rigging tackle. Small towers can ordinarily be erected by a crew of men without special rigging. This also applies for an A-frame, or a tower made from two standing trees, provided they are not very high. Expedient tower construction is discussed in detail in chapter 3.

50. Erection Sag

In order to determine the erection sag, figure 158, appendix III can be used. For example, from paragraph 42, the sag when at the center when loaded is given as 100 feet on 10 percent. From figure 158, for 10 percent sag and 20 percent slope and 1,000 feet, the ratio is .792 or erection sag is 100 feet x .792 or 79.2 feet. If a tensiometer is used, figure 159 can be used to determine the ratio of unloaded tension to loaded tension.

51. Track Cable Installation

The track cable must first be strung in position and then installed. Mount the reel of track cable on a mandrel supported by jacks at the lower terminal so it can turn freely. Stringing may be done by manpower, hauling the track cable end up the slope to be cover[illegible] [illegible] continuous haul rope is to be used, the haul rope can be strun[illegible] because it is easier to handle and lighter. After the haul ro[illegible] strung, the end of the track cable can be attached to the haul rope and pulled across the gap. This system cannot be used in all installations. After the track cable is strung, it must be rigged. In most cases a fiber rope can be passed over the sheave or saddle at the tower and used to pull over the end of the track cable. If the lower terminal is very high, the carriage or trolley must be placed on the track cable before it is pulled over the tower. At the upper terminal, the end of the track cable can be attached to the anchor sling with a wedge-type cable grip. At the lower terminal, takeup gear must be installed to set the erection sag in the track cable. Takeup gear usually is a tackle made up of double blocks to provide a considerable mechanical advantage. If a tensiometer is to be used, anchor one end of it and attach a rachet chain hoist from the other end to the lead line of the takeup tackle. The takeup gear can be used to establish the required erection sag without a tensiometer by sighting-in the sag. Measure down the amount of sag desired in both towers and place a small target (fig. 47) at each of these two points. Sight between the two targets and haul on the track cable takeup gear until the lowest point on the track cable coincides with the line of sight. Another system is to add the desired amount of sag to one-half the difference in elevation of the

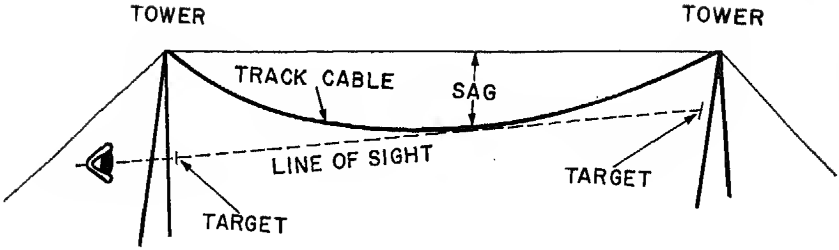


Figure 47. Sighting in sag in track cable.

towers (if there is any). Substract this from the elevation of the top of the upper tower to obtain the elevation desired for the center of the cable. By differential leveling, place a transit in a spot so that the height of the instrument is the same as the elevation desired for the center of the span. Now adjust cable tension until desired sag is obtained.

52. Haul Rope Installation

The haul rope must be pulled into position by manpower, or by winching it into place. Place the reel on a mandrel supported on jacks at the lower terminal and drag the haul rope into place. For a continuous haul rope, pass it through a block at the upper terminal. If takeup tackle is attached to this block, it can be used to haul the slack out of the line. If the block at the upper terminal is fixed, provision for controlling the slack must be made at the lower terminal. There is no requirement of tension on the haul rope except that when a continuous arrangement is used there must be enough tension to prevent slippage on the power unit drive spool. The haul rope should never have less sag than the track cable. If this condition should develop, there would be a constant chafing action on the track cable at the two points where they would cross.

Section III. SPECIAL APPLICATIONS

53. Purpose

Cableways and tramways can be used in a wide number of special applications in the field. The supply of isolated units and evacuation of battle casualties are well known uses. Emergency use to provide a stream crossing for materials and personnel during bridge construction is another application. Movement of supplies in heavy snow, use as a dragline, use in bridge construction, and ship-to-shore movements are additional special applications.

54. Toboggan Hauling Unit

A toboggan hauling unit can be rigged for use in deep snow with a minimum of construction time. No track cable is required. A con-

tinuous haul rope is strung and passed through a snatch block at the upper terminal. At the other terminal several turns of the haul rope are made around the drive spool of a power unit. A toboggan is fastened to the connection between the ends of the haul rope and pulled back and forth when the power unit is operated.

55. Dragline Cableway

A cableway can be rigged as a dragline. This is particularly effective when cutting in a streambed. The track cable is secured in place so that it closely parallels the slope (fig. 48) which is to be dragged. Attach the scraper bucket to a carrier or trolley on the track cable. Attach a single haul rope from the carrier to the dump area and power it with a winch. Depth of cut is easily controlled, since the scraper can dig no deeper than the supporting carrier will permit. Gravity is used to return the empty scraper to the cutting position.

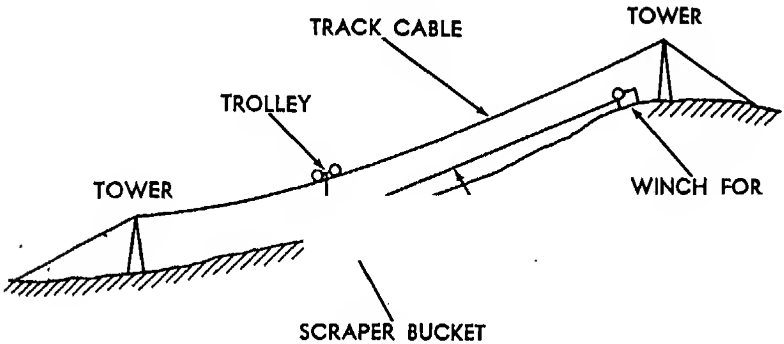


Figure 48. Cableway used as dragline.

56. Ship-to-Shore Cableway

Ship-to-shore cableways are very useful under many circumstances. They are difficult to rig, however, because of the motion of a ship. Even when anchored or moored, a vessel moves on the surface of the water with the tides and rolls with the waves. Any track cable secured to a mast of the vessel is subjected to changing tension because of this. If a vessel is moored in calm water near the shore (fig. 49), a light cableway can be used temporarily, but much more sag must be allowed in the track cable than would ordinarily be the case. This is to prevent snapping of the eable from sudden motion of the ship. A quick-release device should be placed on the anehorage of the track cable for emergency use.

57. Bridge Construction

Cableways have proven invaluable in some eases of bridge construction for moving materials to piers under eonstruction in mid-

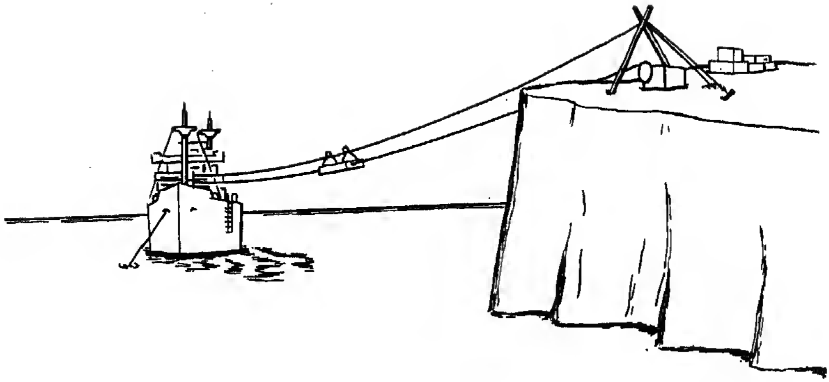


Figure 49. Light ship-to-shore cableway.

tream (fig. 50). Steel or wood members, partially prefabricated arts, concrete, tools, and personnel can quickly and easily be moved ɔ the pier by cableway. The cableway is so constructed that its enterline is on the centerline of the bridge. A fall rope is rigged ig. 45) so the loads can be lowered into position at the pier. Because f the restricted working space on the pier it is usually helpful to put ɩg lines on the load and use signals or radio communication to direct

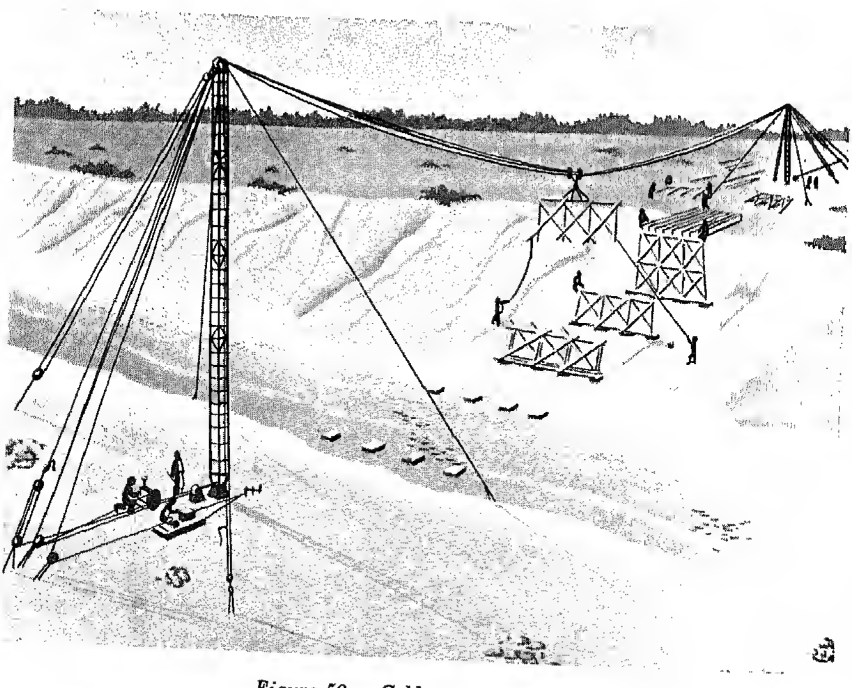


Figure 50. Cableway erection.

the power unit and hoist unit operators. In addition to placement of piers, cableways can be used for placing long stringers as illustrated in figure 51. The capacity must be checked to insure that the cable and carriage will have sufficient capacity for heavy beams.

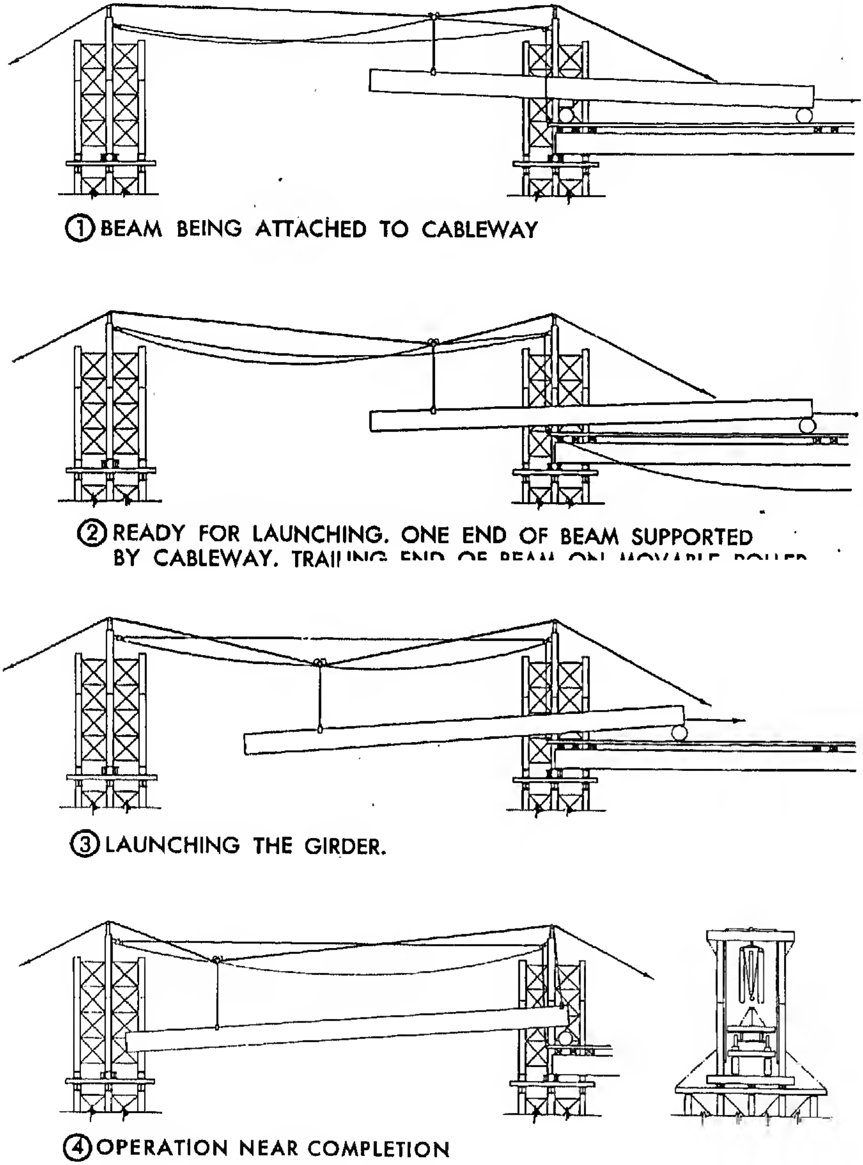


Figure 51. Launching heavy beam by cableway.

CHAPTER 5

SUSPENSION BRIDGES

Section I. DESIGN FACTORS

'. Introduction

As previously stated (para. 6), suspension bridges are limited to atively light loads (personnel or light vehicles). Application of › following information will enable the selection of components, der various conditions, necessary to erect suspension bridges. idging for heavier loads requires more careful and complete comtations and is beyond the scope of this manual.

.'. Recommended Factors

Figure 52 illustrates the location of the various factors used in suspension bridge design.

a. Dip (*y*) *and Sag Ratio* $\frac{(y)}{s}$. Dip and sag control the strength and stability of the bridge. The sag ratio varies from $\frac{1}{20}$th or 5 percent to $\frac{1}{6}$th or $16\frac{2}{3}$ percent. If the main cables have a flat curve or low sag ratio, the bridge has more vertical stability, but cable stress is high and strong anchorages are required. If the sag ratio is high, there is less stress on the cable and the anchorages may be placed closer to the towers.

b. Camber (*c*). Camber allows for deflection of the bridge under load. It is the vertical distance from the top of the floorbeam in the middle of the span to a straight line drawn between the tops of the tower sills. A camber equal to 0.67 percent of the span length normally is used.

c. Cradle (*k*) *and Flare* (*f*). Cradle and flare help steady the bridge. Cradle is the lateral distance from the midpoint of one of the main cables to a straight line drawn between its points of support on the near and far shore towers. It is usually 1.25 percent of the half-span length. Flare is the lateral distance from the cable support on the towers to the cable at the anchorage. Flare is usually 2.5 to 3.5 percent of the horizontal backstay length (fig. 52).

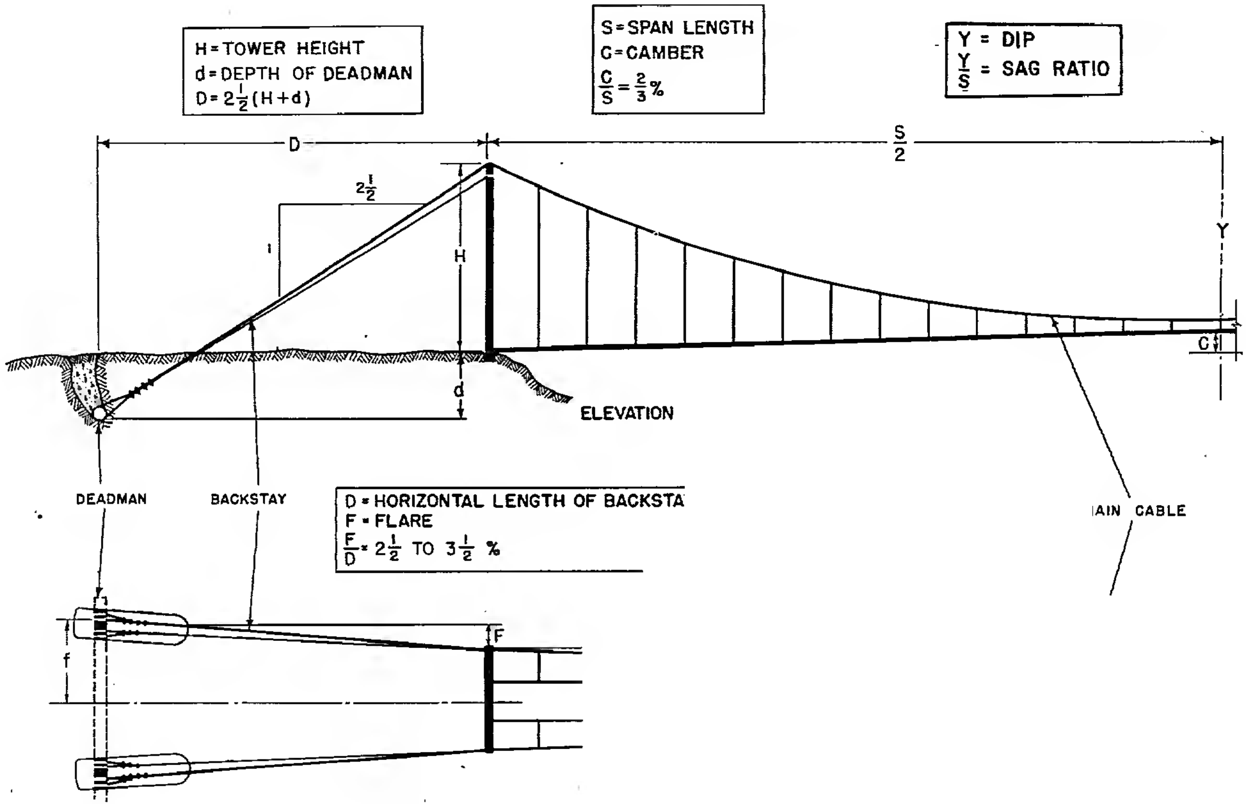


Figure 52. Design

733-540 O—64——5

d. Backstay Slope $\left(\frac{H+d}{d}\right)$. Backstay slope is the ratio of the vertical difference in level between the deadman and tower support of the main cable to the elevation difference from the deadman to the tower. If the angle of the backstay and main cable are the same at the tower, the stress will be equal on both sides of the tower. A backstay slope of 1 to 2½ is usually used.

60. Procedure

a. Design of a suspension bridge requires analysis of the following items.

(1) Load to be carried
(2) Panel length
(3) Floorbeams and stringers
(4) Stiffening truss
(5) Dead load
(6) Suspenders
(7) Main cables
(8) Towers
(9) Tower bracing and backstays
(10) Anchorages

b. The load to be carried is used to design a stiffening truss and floor system. The dead and live loads are then used to select suspender and main cables, towers, and anchorages. The stiffening and floor truss should be designed first, and then the cables, towers, and anchorages selected. The design procedure of a light vehicle bridge will be followed as an example. A 300-foot bridge to carry a 4,000-pound load with a 10-percent sag ratio will be designed.

61. Loads

Loads to be used in designing a suspension bridge can be either a uniform load or a concentrated load. A uniform load condition may be considered, if five or more concentrated loads are carried on the bridge at one time. This simplifies design to a great extent. Impact loads will be considered in cable selection but may be disregarded for timber design. For suspension bridges, an impact load equal to the live load will be used. In designing the floor and siderail system, the dead load and live load are used. The dead load, live load, and impact are used for cable design.

Section II. FLOOR AND TRUSS DESIGN

62. Panel Length

A typical floor and truss section of a bridge is shown in figure 53. The truss helps spread the load over several panels and also stabilizes the bridge. For some very light footbridges, a truss may be omitted

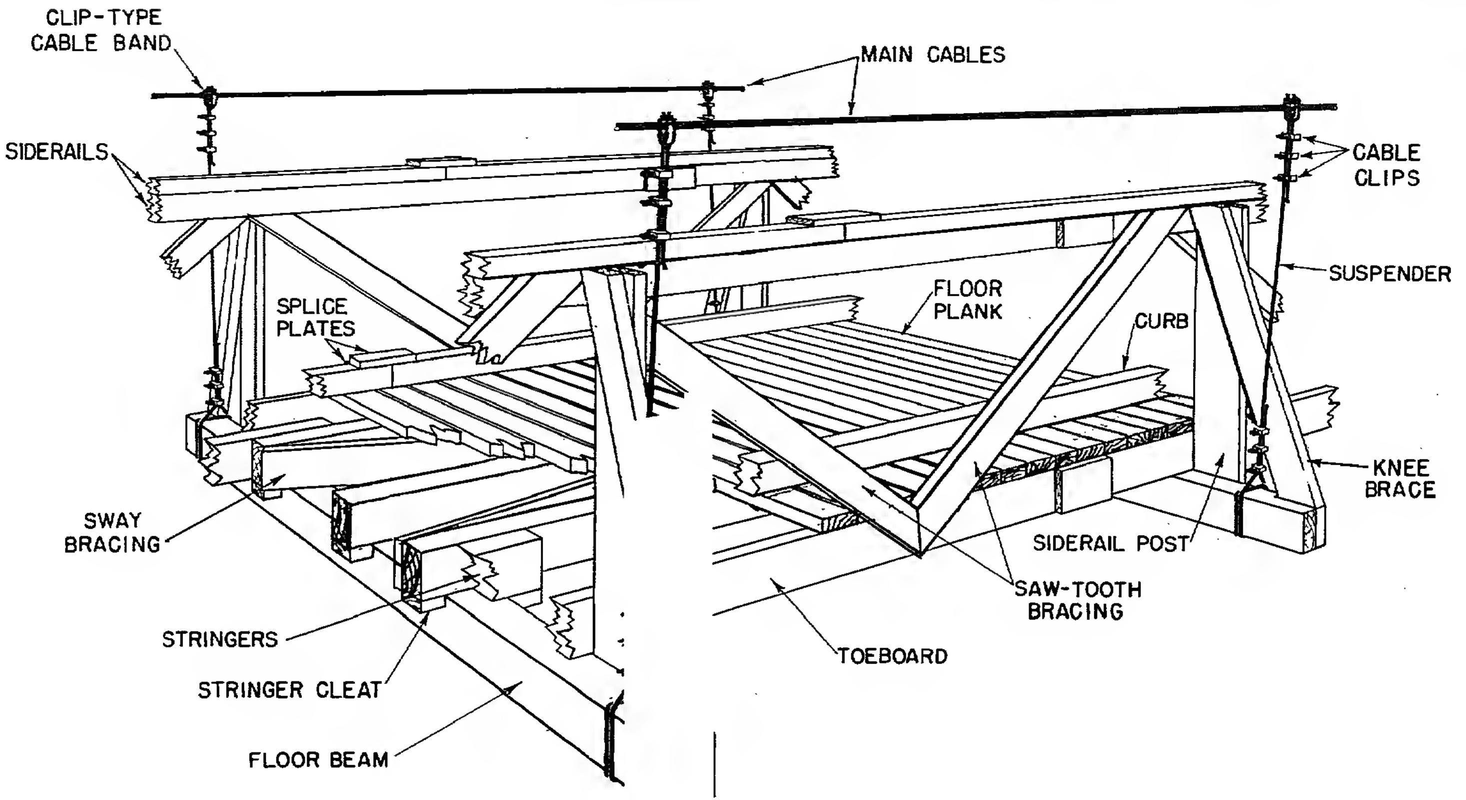


Figure 53. *anel for suspension bridge.*

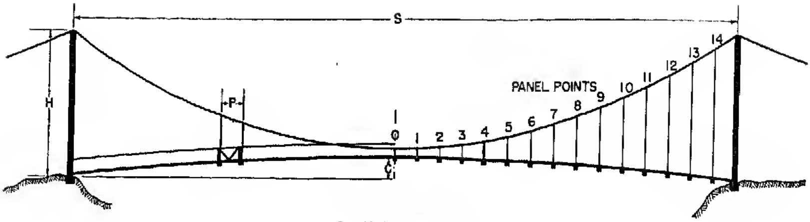


Figure 54. *Panel numbering.*

with only a roadway and posts suspended from the main cables. A panel length must be assumed to enable selection of the components. Normally, panel length will be between 10 to 15 feet. A 10-foot panel usually is a practical length. Panels are numbered symmetrically from 0 at the center suspender outward to the towers as shown in figure 54.

63. Stringer Design

a. Table III can be used to select stringers. A uniform loading and an allowable stress of 1,000 psi are used for the table. If a concentrated load is used, half the load values are used. For other than an allowable stress of 1,000 psi, the load is multiplied by the allowable stress over 1,000. Given an available size of stringer, panel span, and load to be carried, the number of stringers required may be determined by dividing the value in column 5 by the span length in feet, multiplying by the allowable stress, and dividing by 1,000.

b. Example. A 4,000-pound concentrated load is to be carried on a 10-foot span by 4- by 6-inch planks, with an allowable bending stress of 2,400 psi, joining down column 1 to 4 x 6 and across to column 5, the allowable load for a 4 x 6=12,740 pounds. For a 10-foot span and a concentrated load:

$$\frac{12740}{2(10)} \times \frac{2400}{1000} = 1530 \text{ pounds per stringer.}$$

Number of stringers required:

$$\frac{4000}{1530} = 2.6 \text{ or } 3 \text{ stringers.}$$

64. Floorbeams and Planks

a. The floorbeams transmit the loads from the stringers to the suspenders. Suspender cables are wrapped around the floorbeams. The floorbeams are extended beyond the roadway so that knee

braces may be used to support the siderail posts. Table IV gives the size floorbeam to be used with various loads.

b. Floor planks act as the tread and spread the load to the stringers. For personnel 2-inch planking is sufficient. Vehicular loads will require 3-inch planking.

65. Siderails and Posts

On very light or short footbridges, siderails are not necessary. As the span increases and the load to be carried increases, siderails must be added to stabilize the bridge. On light footbridges, 2- by 4-inch posts and siderails can be used with single siderails being sufficient. Heavier vehicular bridges require 3- by 6-inch posts with double siderails and toe board as shown in figure 53 should be used. Posts should be approximately 3 feet 6 inches long for safety and convenience.

Table III. Properties of Wooden Beams

Nominal size in. (1)	Actual size in. (2)	Area of section (3)	Weight per lineal foot w=40 pounds per cubic ft (4)	Maximum safe uniform load based on bending on 1-foot span f=1,000 psi (5)
4×6	3⅝×5⅝	20. 4	5. 66	[illegible]
6×6	5½×5½	30. 3	8. 40	[illegible]
4×8	3⅝×7½	27. 2	7. 55	[illegible]
6×8	5½×7½	41. 3	11. 4	[illegible]
8×8	7½×7½	56. 3	15. 6	46, 900
6×10	5½×9½	52. 3	14. 5	55, 200
8×10	7½×9½	71. 3	19. 8	75, 200
10×10	9½×9½	90. 3	25. 0	95, 300
6×12	5½×11½	63. 3	17. 5	80, 000
8×12	7½×11½	86. 3	23. 9	110, 200
10×12	9½×11½	109. 3	30. 3	139, 600
12×12	11½×11½	132. 3	36. 7	169, 000

Table IV. Floorbeam Size for Given Load

Load	Floorbeam cross section
Foot troops with fullpack	4 by 6 inches
¼-ton truck with normal load	6 by 6 inches
¾-ton weapons carrier with normal load	8 by 8 inches

66. Bracing

There are three types of bracing used on the truss of the suspension bridge (fig. 53). Saw tooth bracing helps to stiffen the truss and spread the load over several panels. For this use, 2- by 6-inch lumber

is satisfactory. Knee bracing is used to hold the posts and floorbeams. The floorbeams must be extended to allow for the knee braces. For knee bracing 2- by 4-inch material can be used. Sway bracing helps to stabilize the bridge laterally. On light bridges, heavy gage wire may be used with rack sticks as shown in figure 55. Heavier bridges require timber sway bracing as shown in figure 56.

67. Dead Load

a. Once the components of the truss and floor system have been selected, the dead load may be determined. The dead load is cal-

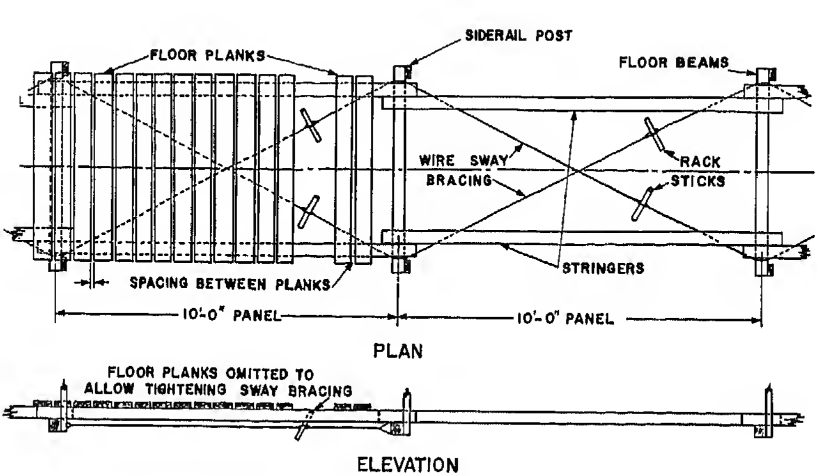


Figure 55. Wire sway bracing.

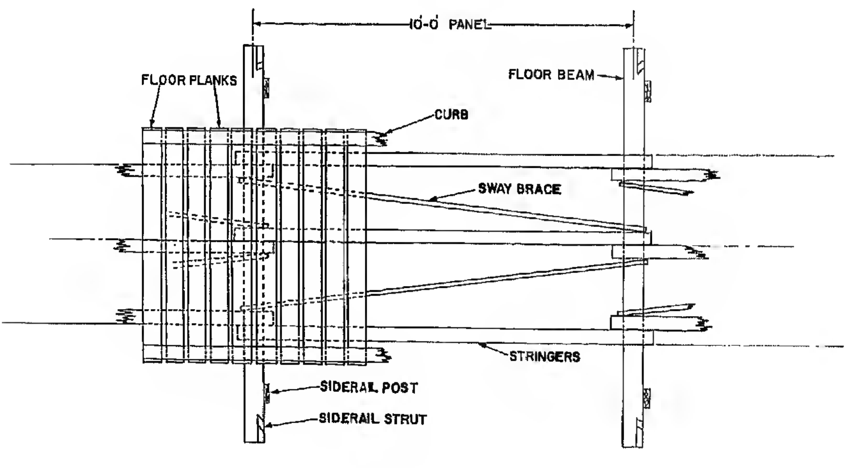


Figure 56. Timber sway bracing.

culated in pounds per panel. From figure 53, the dead load per panel includes the following:

2 suspenders	2 knee braces
1 floorbeam	4 braces
2 stringers	2 to 4 siderails
2 toeboards	2 curbs (if used)
2 side posts	cable clips and bands
20 floor planks	

b. Example (from table III for weight of lumber).

2 suspenders	10 ft @ .40 lb/ft	=8 lb
1 floorbeam	6 x 6 x 10 ft @ 8.40 lb/ft	=84 lb
20 deck planks	3 x 6 x 5 ft 10 in. @ 4.10 lb/ft	=479 lb
3 stringers	4 x 6 x 11 ft @ 5.66 lb/ft	=186 lb
4 toeboards	2 x 6 x 10 ft @ 2.54 lb/ft	=102 lb
2 side posts	2 x 6 x 3 ft 10 in. @ 2.54 lb/ft	=19 lb
2 knee braces	2 x 4 x 4 ft 1 in. @ 1.64 lb/ft	=13 lb
4 braces	2 x 6 x 5 ft 8 in. @ 2.54 lb/ft	=58 lb
4 siderails	2 x 6 x 10 ft @ 2.54 lb/ft	=102 lb
2 curbs	4 x 4 x 10 ft @ 3.65 lb/ft	=73 lb
clips	10 lb	10 lb
		1,134 lb/10 ft

Section III. CABLE AND TOWER DESIGN

68. Basic Considerations

Once the dead load per panel has been determined, the suspender and main cables are selected. The tower components and anchorages are then selected from the amount of tension the cables will have. The impact load must now be included in the design procedures.

69. Suspenders

a. Design. Suspenders are designed to carry the live load, impact, and dead load. Dead load per panel calculation was covered in paragraph 67. The live load is assumed to be equal to the gross weight of the desired load. Impact load is assumed equal to the live load. The weight per suspender is equal to one-half the sum of the loads. The size of suspender is then selected using a safety factor of 5.

b. Example.

Dead load	1,134 pounds
Live load	4,000 pounds
Impact load	4,000 pounds
Total load	9,134 pounds

$$\text{load per suspender} = \frac{9{,}134}{2} = 4{,}567 \text{ pounds}$$

From table XVIII, appendix II, for ⅝-inch diameter improved plow steel 6 x 19 wire rope, the breaking strength is 16.6 tons.

The allowable then is $\frac{(16.6)(2{,}000)}{5}=6{,}640$ pounds

The next smaller size rope will not carry the required load; therefore, ⅝-inch wire rope must be used.

70. Suspender Length

a. In order to determine the effective length, or distance from main cable to floorbeam, of suspenders, the following formula is used:

$$h=L+\left(\frac{n}{N}\right)^2(C_0+y)$$

Where h=effective suspender length
L=effective length of center suspender
n=panel point of suspender
N=panel point of tower
c_0=camber of the bridge in ft
y=dip or sag of main cable in ft

b. Example. For panel point No. 5.
L=2.5 feet
n=5
N=15
C=2 feet
y=30 feet

$$h=2.5+\left(\frac{5}{15}\right)^2(2+30)=6.05 \text{ ft}$$

The cut length should include sufficient length to wrap around the floorbeams and form a loop to attach the suspenders to the main cable. An additional 5 to 6 feet added to the effective length is sufficient. The loop must have a thimble included to prevent shearing of the suspender cable.

71. Main Cable Design With Uniform Load

a. The main cables are designed using the formulas in paragraph 19 or table II. A uniform loading can be determined by dividing the load by the span.

b. Example. A bridge with a 300-foot span is to carry five 4,000-pound vehicles spaced evenly across the bridge. The uniform load is—

$$w=\frac{(5)\ (4000)}{300}=66.7 \text{ pounds/foot.}$$

Using the live load and impact load to be carried, plus the dead load of the bridge as the total uniform load, a cable size is assumed and the calculations performed using formulas from paragraph 19*a*. A live

load of 66.7 pounds, impact of 66.7 pounds, and a dead load of 113.4 pounds per foot, gives a total load of 255 pounds, per foot. Assuming a 10 percent sag ratio for a 300-foot bridge, the sag (y_c) will be 30 feet. A 1⅛-inch diameter improved plow steel wire rope will be assumed That weight per foot from table XVIII, appendix II, is 2.03 pounds per foot.

Total load is live load--
Impact load---
Dead load---
Main cable weight--

Total load=--
Use 255 pounds per foot:

(1) From formula 2, paragraph 19*a*, horizontal tension is

$$t=\frac{(255)(300)^2}{8(30)}=\frac{22,950,000}{240}=95,600$$

From formula 4, paragraph 19*a*,

$$\text{Tan}\ \beta_1=\frac{4(30)}{300}=.4,\ \beta_1=21°\,50'$$

$\text{Sec}\ \beta_1=1.077$

From formula 3, paragraph 19*a*, tension in the cables is—

$t^1=(95,600)\ (1.077)=103,000$

The breaking strength of 1⅛-inch IPS wire rope is 106,000 pounds. If four cables are to be used, the allowable tension with a safety factor of 4 is $\frac{(4)(106,000)}{4}=106,000$ pounds for 4 cables, or $\frac{106,000}{4}=26,500$ for one cable. The tension in the cables will be $\frac{103,000}{4}=25,750$ pounds per cable or within the allowable tension for 1⅛-inch IPS wire rope. The length of cable between supports will be from formula 5

$$L=300(1+\frac{8}{3}(.1)^2)=300(1+.026)$$

L=309 feet.

(2) Using table II, for a 10 percent sag ratio in column 1; from column 2 for cable tension, the factor 1.35 is determined; from column 4 for cable length, the factor is 1.026. The tension and length are—

t=(255) (300) (1.35)=103,000 pounds

L=(300) (1.026)=309 feet

72. Backstays

ʰᵃ portion of the main cable behind the towers or the backstay checked to insure that the maximum allowable tension of the ıot exceeded. The tension in the backstay may be determined ıplying formula 2 by the secant of the angle of the backstay ' ·izontal. To have the equal tension in the cable on both ower the backstay angle (fig. 53) with the horizontal

$\overline{16k^2}$

the sag ratio $\frac{Y_c}{s}$

73. Tower Dimensions

a. Chapter 3 covered the various types of towers which can be used for suspension bridges. The tower height is determined by taking the sag ratio $\underline{Y_c}$ plus the percentage of camber c times the span, and adding

ɔf the center suspender.

00-foot span, 10 percent sag ratio, .67 percent ɛııɛctive length center suspender of 2½ feet.

,ɑt=(300) (.10+.0067)+2.5

=300 (.1067)+2.5

=32.1+2.5=34.6 feet

This is the distance from the top of the sill to the main cable. The width of the tower is determined by the load to be carried with a minimum of 4 feet for personnel.

74. Post Size

a. The post size of the towers is determined by the vertical reactions of the main cables. For simplicity, a 12- by 12-inch post will carry loads up to 2½-ton truck. If, however, the minimum size that can be used must be determined, table V and table XVII, appendix II may be used. From table XVII, appendix II, the maximum vertical reaction for a particular sag ratio, slope and tieback may be determined. Using this value, a post size may be determined from table V.

b. Example: For two 1⅛-inch cable, 10 percent sag, 0 percent slope, 1 to 2 tieback, and a 34.6-foot high tower, what size post can be used? From table XVII, appendix II, the load for two 1⅛-inch cable, 10 percent sag, 0 percent slope, 1 to 2 tieback is 19,400 pounds for each cable or 38,800 for two cables. First a post size must be assumed and the $\frac{l}{d}$ or $\frac{\text{length in inches}}{\text{minimum depth in inches}}$ must be determined and the actual

area in square inches. Assume a 10-by 10-inch post of a material with an E (modulus of elasticity) of 1,600,000.

$$\frac{l}{d}=\frac{(34.6)\ (12)}{10}=41.6$$

Area = 90.3 square inches.

From table V, for $\frac{l}{d}$=45 and E=1,600,000, the allowable stress is 356 pounds per square inch.

(356) (90.3)=32,100 which is insufficient.

Assuming a 10- by 12-inch timber can be used, the $\frac{l}{d}$ will be the same, but the area will be 109.3. Therefore, for a 10- by 12-inch timber (356) (109.3)=38,900 which is sufficient.

A 10- by 12-inch post can be used. Bracing of the towers should be 2-inch lumber. Saddles and saddle blocks as covered in paragraph 23 and figure 20 should be placed on top of the posts to protect them from the cables.

Table V. Working Stress for Timber Columns Compression Parallel to Grain[1]

L/d in/in

E	15 or less	20	25	30	35	40	45	50
1,000,000	1,800	1,125	720	500	366	282	222	180
1,100,000	1,800	1,230	790	550	404	309	245	196
1,200,000	1,800	1,350	862	600	441	337	267	216
1,300,000	1,800	1,460	930	650	479	366	290	234
1,400,000	1,800	1,575	1,010	700	515	395	311	252
1,500,000	1,800	1,675	1,080	750	550	422	333	270
1,600,000	1,800	1,800	1,150	800	588	450	356	288
1,700,000	1,800	1,800	1,225	850	624	479	378	306
1,800,000	1,800	1,800	1,295	900	660	507	400	324
1,900,000	1,800	1,800	1,370	950	696	534	422	342
2,000,000	1,800	1,800	1,440	1,000	735	562	444	360

[1] Based on $\frac{P}{A}=\frac{.45\ E}{(L/d)^2}$

75. Anchorages

Types of anchorages were covered in chapter 3. The tension that must be withstood by the anchorages are the same as the backstay tension as determined in paragraph 72. A deadman type of installation for the main cables is usually the most satisfactory. If the back guy is anchored to the same deadman, the pull must also be included in determining the holding power required. More detailed coverage on anchorages is contained in TM 5–725.

Section IV. CONSTRUCTION PROCEDURE

76. Site Layout

The site for the bridge must have sufficient area available for assembly of the towers and hangers. Normally, stadia distances provide sufficient accuracy. The distance between towers must be divisible by 20 if 10-foot panels are to be used. The tower sites must be checked to insure that the towers will be perpendicular to the centerline of the bridges. The distances to the deadmen should be ...ured and marked.

...ay

...sion bridge construction, a cableway should be ... of the site of the bridge. The cableway is used ...nd materials across the gap in order to allow ...ge from both banks simultaneously. Once the ...nel are across and the main cables erected, the ...dismantled and the wire rope used as guy lines if

... of Towers

... the sites for the towers have been marked, the area for the sills must be leveled. If footings are needed, the cleared foundation area must be large enough to accomodate them. As the sills are being prepared, the towers are assembled and the deadmen prepared. The towers are erected and braced with side and back braces. Methods for erecting heavy towers can be found in chapter 3.

79. Placing Main Cable

When the towers are erected and deadmen in position, the main cables are placed. A lead line is attached to the main cable and carried across the gap by the cableway. If the main cables are on reels, these are placed behind the towers and the cable guided over the near tower and pulled across to the far tower. The cables are then passed around the deadmen and temporarily clipped in place. A ratchet chain hoist is used to set the cable to the proper sag as covered in paragraph 51. When the cable is properly set, the clips are set and tightened.

80. Assembling Hangers

The floorbeams, posts, knee braces, and suspender cables are assembled together to form hangers (fig. 57). After the posts, braces, and floorbeams are assembled, the suspender cables are wrapped once around the floorbeams and then clipped. The floorbeam should be notched to avoid sharp bends in the cables. The effective length of the suspender is then measured and a thimble installed on the cable

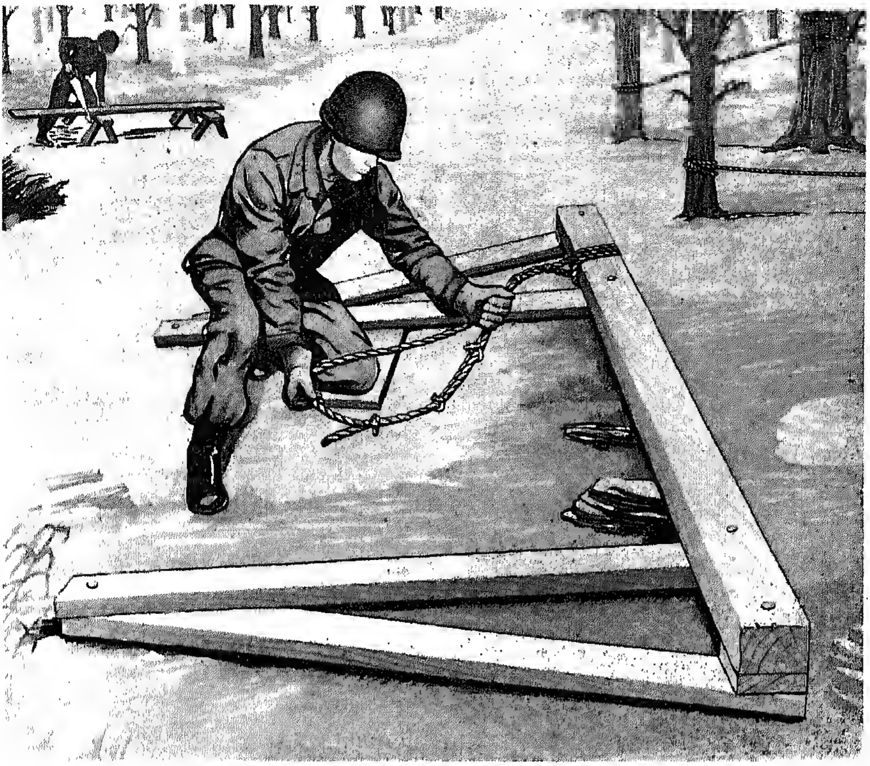


Figure 57. Completed hanger assembly.

and the cable clipped. The effective length is the length when the cable is taut and should be rechecked when the bridge is complete.

81. Erection Scaffold

An erection scaffold is used to place the hangers (fig. 58). Hangers are placed simultaneously from both sides of the bridge. The assembled hangers are given to two men on the erection scaffold who fasten the suspenders to the main cable and then slide them to the proper location (fig. 59). The clips are not tightened until the stringers are set (para. 80).

82. Placing Stringers

When the first hanger is positioned, the stringers are then placed and nailed to the sill and floorbeams (fig. 60). The suspenders are made vertical and the cable clips tightened. The next hanger is brought forward and the procedures repeated with the stringers nailed to the floorbeams. Cleats are nailed to the underside of the stringers to keep them in place on the floorbeams.

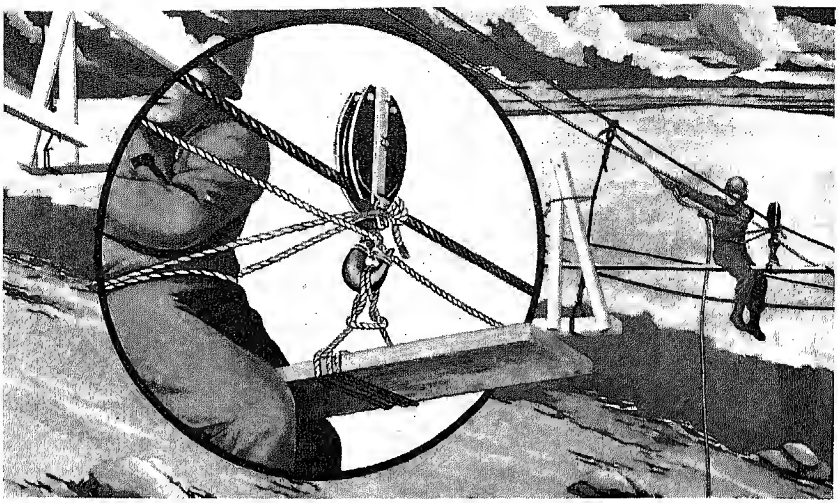


Figure 58. Erection scaffold.

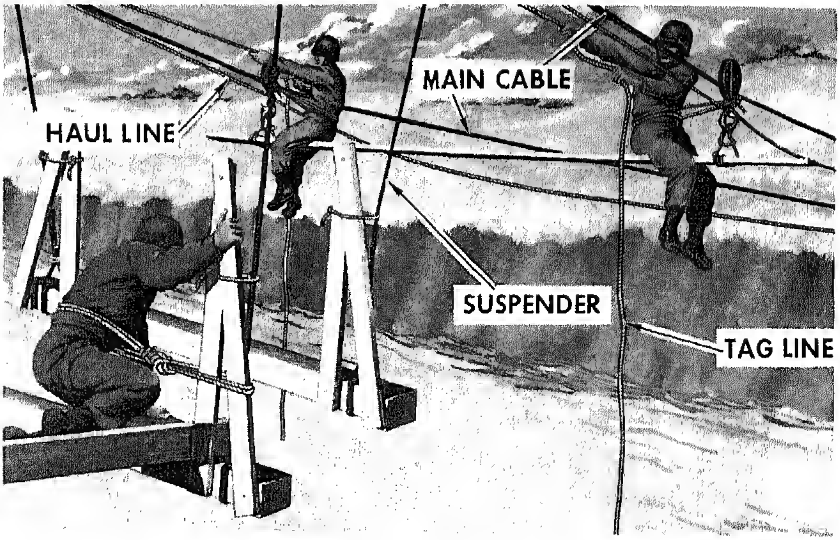


Figure 59. Placing hanger.

83. Flooring and Sway Bracing

If timber sway bracing is used, it must be nailed in place before the floor planks are placed. The sway bracing is placed diagonally and nailed in place, then the flooring with ¾-inch spacing is nailed down. If wire sway bracing is used, the flooring can be placed omitting boards to allow the installation of the wire bracing. The wire sway bracing is installed and both wires tightened simultaneously with rack sticks. The floor boards are then placed to hold the rack sticks in place.

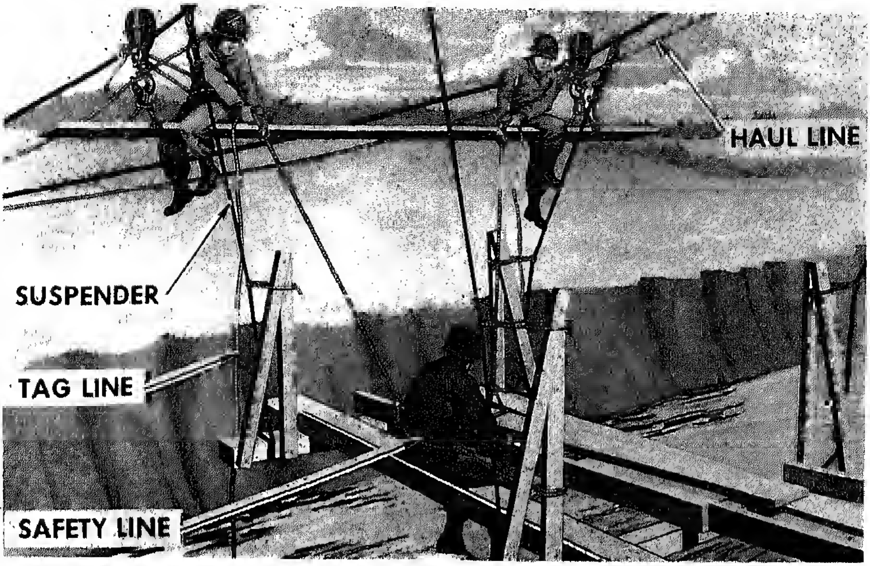


Figure 60. Placing stringers.

84. Siderails and Toeboards

Upon completion of the flooring, the siderails and toebo curbs are installed. Splices should be made 2 to 3 feet from tL rail posts. Splice plates should be used for all splices. The saw bracing is installed following the siderails and toeboards or curbs.

85. Testing Bridge Capacity

Upon completion all cable connections should be rechecked to insure that the suspenders are vertical and all cable connections secure. The bridge should then be tested with light loads before the full capacity is applied.

Section V. TYPICAL BRIDGES

86. Footbridge

A footbridge, designed for crossing foot troops at 3-pace intervals at spans up to 150 feet, is illustrated in figures 61 and 62. A 5-percent sag ratio is used. The main cables support the flooring and the handrail cables assist in carrying the load. The floor beams are 4- by 4-inch lumber and the flooring is 2- by 6-inch lumber. The posts or stanchions are 6-inch logs with 12-inch logs as end posts.

87. Suspended Walkway

a. Description. Pipe stanchions, as shown in figure 63, may be fabricated for use with short span footbridges. They are fabricated from 1 inch standard pipe and cable clips and may be used to construct

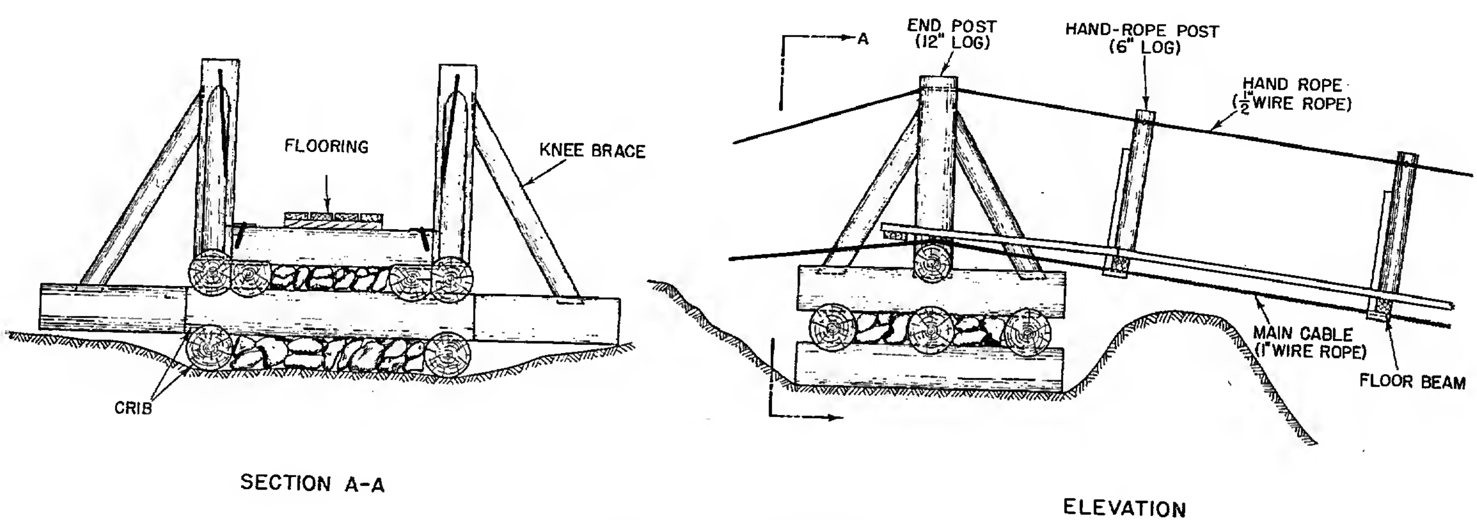


Figure 61. Footbridge design.

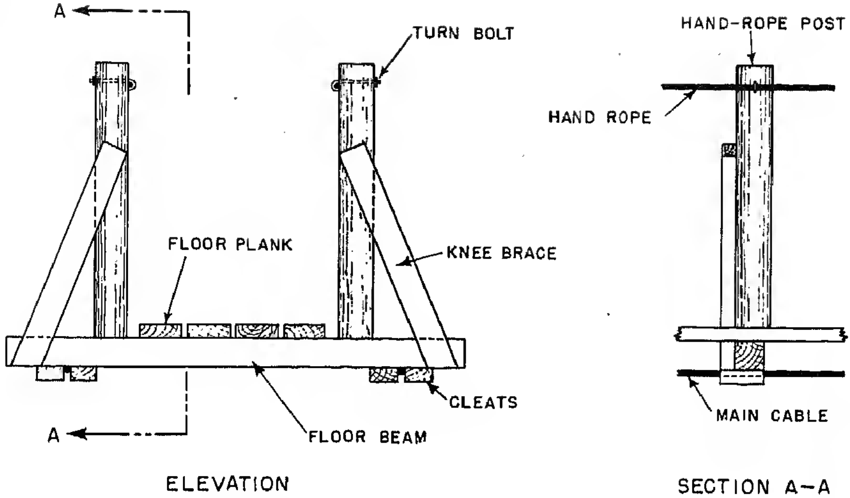


Figure 62. Hanger assembly for footbridge.

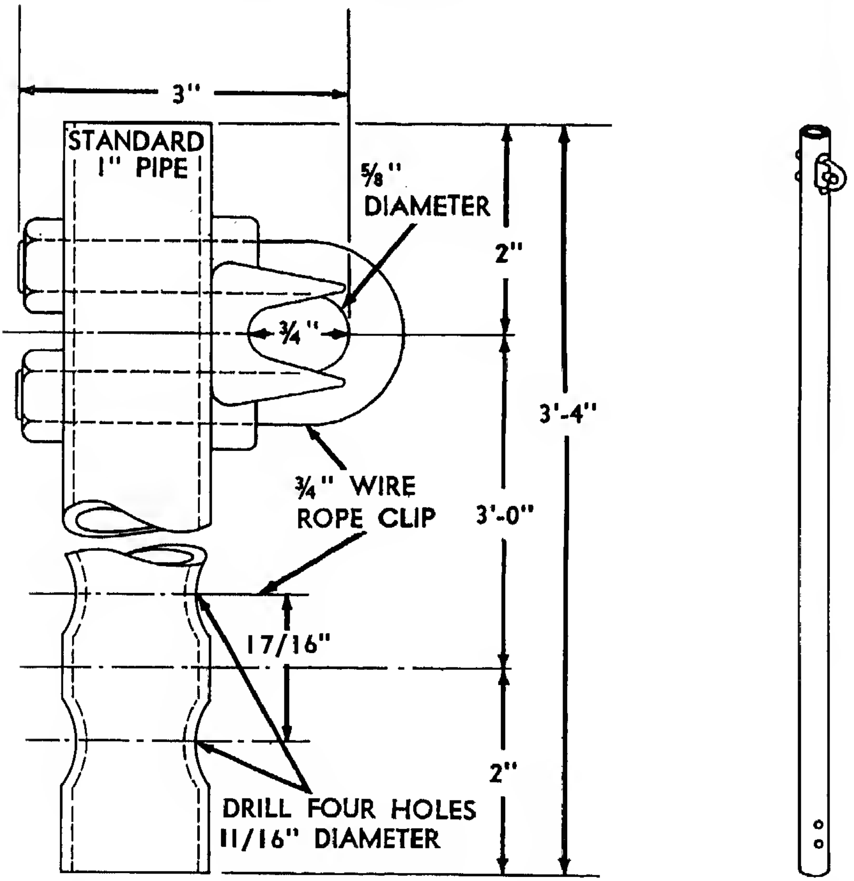


Figure 63. Details of an iron pipe stanchion.

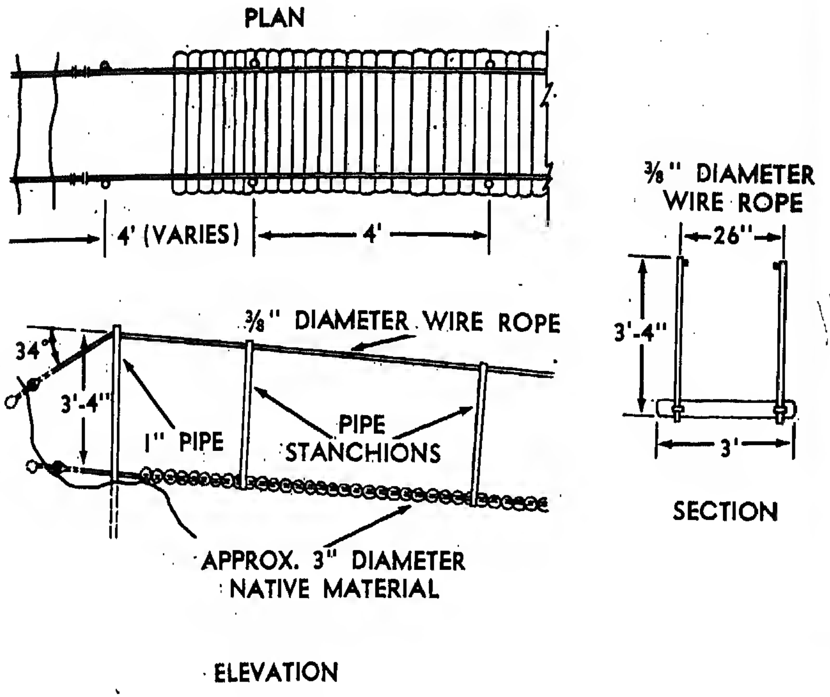


Figure 64. Suspended walkway of native material.

a suspended walkway as shown in figure 64. The walkway can be used for spans up to 70 feet with a 5 percent sag. The treadway is made from native logs approximately 3 feet long and 3½ inches in diameter. The cables are ⅜-inch diameter rope, placed 26 inches apart. A slot, about 1-inch deep, is cut in the logs to fit over the supporting wires.

b. Assembly. The walkway is assembled by first anchoring the end stanchions and the cables. The remaining stanchions are assembled loosely on the cables with the clips but are not tightened. The logs are placed progressively from one side to the other, pushing the vertical stanchions ahead of the work. As the logs are placed, galvanized wire is woven around the logs. The first wire is passed over the first log and the second wire under it, then the wires are crossed and the first wire is passed under the second log and the second wire over it, as shown in figure 65. The wires are woven in this manner until the position for the first pair of vertical stanchions is reached. Then an additional vertical notch is placed in the logs to go on each side of the stanchions, as shown in figure 65. At this point, the stanchions are fixed in place by tightening the U-bolts firmly. Then one notched log is placed on the near side of the stanchion and one on the far side and the wire is woven around them. This procedure is continued until the position for the next stanchion is reached and is repeated as necessary.

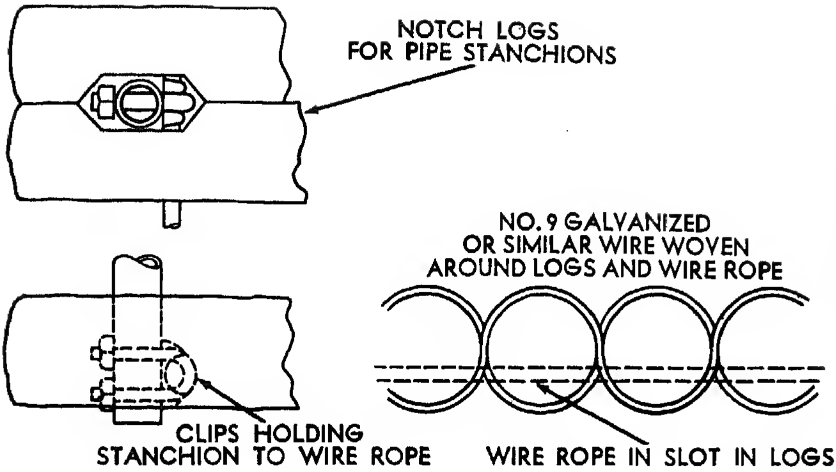


Figure 65. Fastening logs in place.

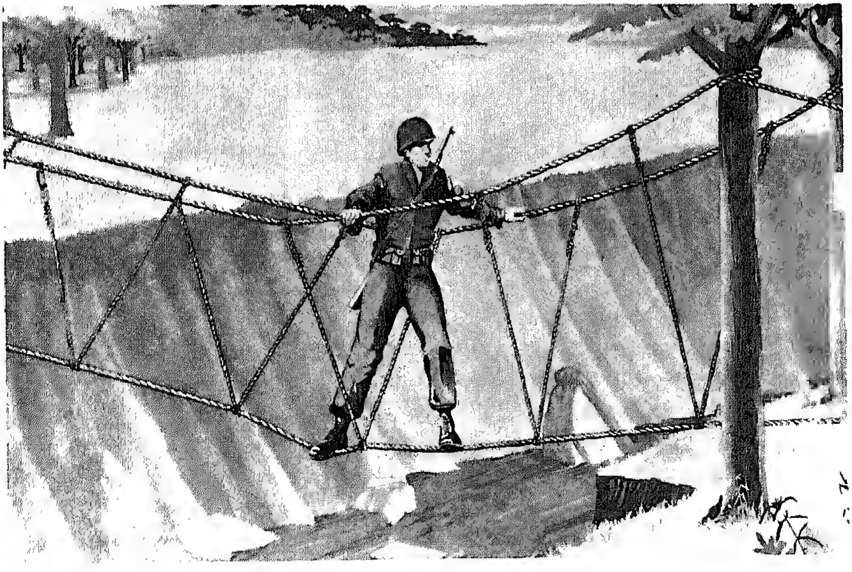


Figure 66. Three-rope suspended walkway.

88. Three-Rope Bridge

a. Components. A rapidly erected bridge with a minimum of materials may be constructed using three fiber ropes (fig. 66) or wire rope cables (fig. 67). The span should not exceed 150 feet as longer spans will be unstable when loaded at midspan. Trees of 10-inch diameter are required for anchorages for the tread ropes, and 8-inch diameter for the hand ropes. The fiber rope bridge is constructed of 1-inch tread rope, ¾-inch hand ropes and 1½-inch suspenders. If

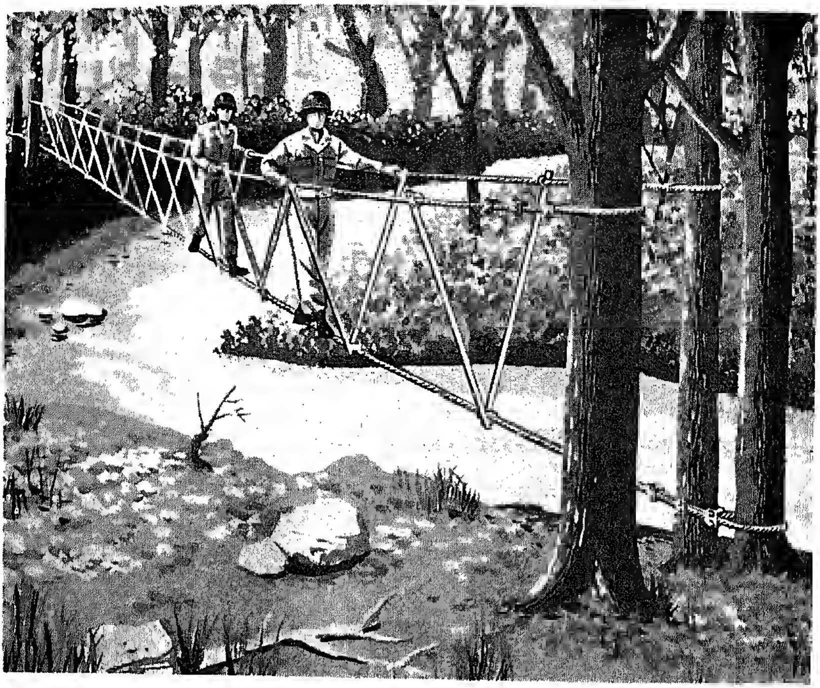


Figure 67. Walkway with cable and pipe stanchions.

wire rope is used, ⅜-inch diameter will be satisfactory. Suspenders for wire rope can be fabricated from wire rope and cable clips or of 1-inch pipe stanchions as described in paragraph 87.

b. Erection Procedures.

(1) The length of the required span may be determined by tying tape or a line across the gap and allowing it to sag 5 percent. The required length must be sufficiently longer to allow for lashings to the anchorages.

(2) The tread and hand ropes are laid out as shown in figure 68. The ropes are placed 3 feet apart. Suspender ropes, cut 12 feet long, are placed at 2-pace intervals. If stanchions are used, the same interval is used.

(3) The suspenders are attached to the tread rope. A clove hitch is used in fiber rope. The two ends of the suspender ropes pass under the tread rope as shown in figure 69. Wire rope suspenders or pipe stanchions are attached with wire rope clips.

(4) The hand ropes are then raised elbow high as shown in figure 70 and the suspenders are attached. For fiber rope, the suspender is tied to the hand rope by a round turn and two half hitches. Wire rope and stanchions are attached with cable clips. All suspenders are attached in a similar

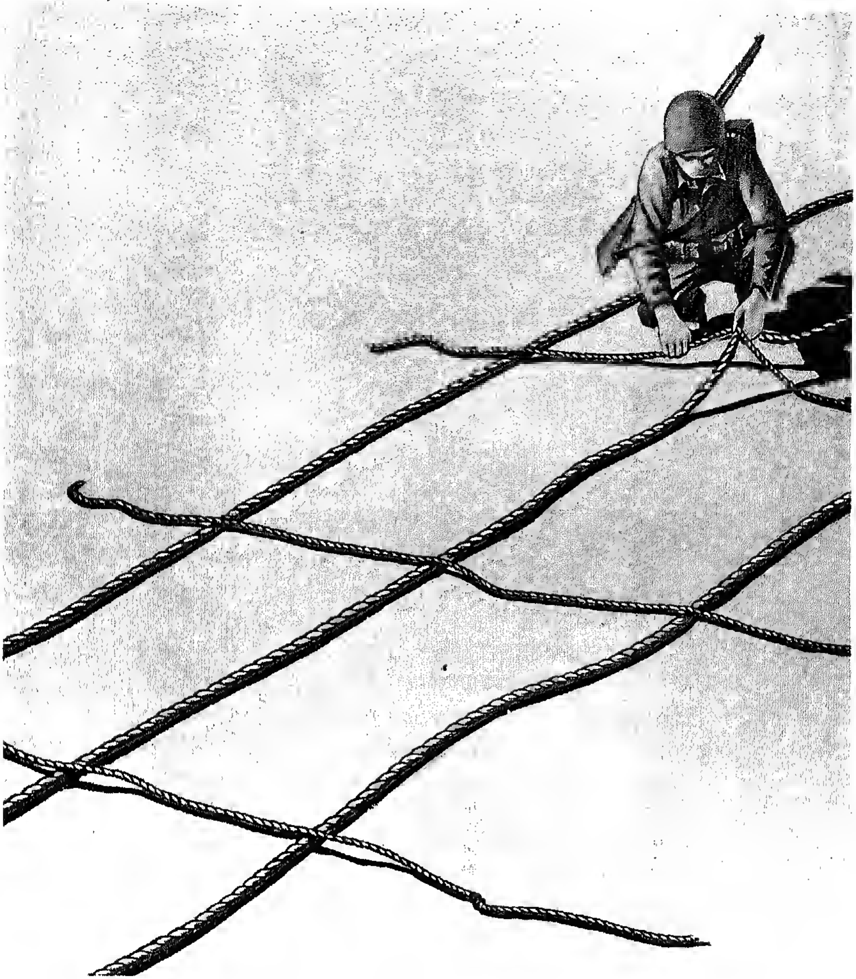


Figure 68. Ropes laid out.

manner. Sufficient length must be left on the tread and hand ropes to make the ties to the anchorage.

(5) The assembled bridge is carried to the bridge site as shown in figure 71. The lines are pulled across the gap and then anchored on the far side with a bowline or a mooring knot. If a bowline is used, an extra turn is taken around the anchorage. The running end are tied back to the standing part with several half hitches. The wire rope is secured with the cable clips after passing around the anchorages. When all ropes are anchored on the far side, the tread rope is adjusted to the proper sag and secured. The hand ropes are then pulled tight and secured.

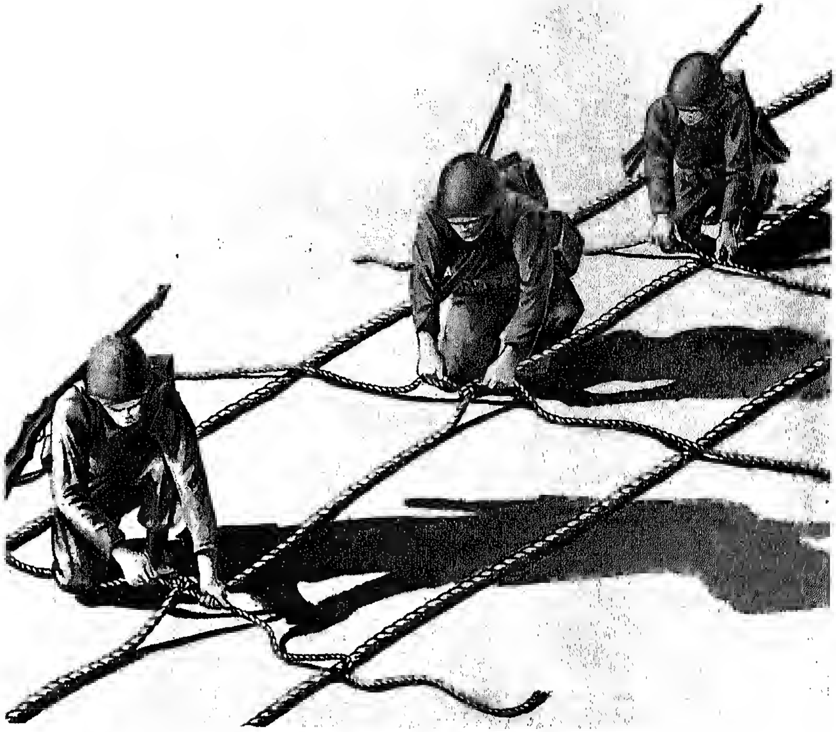


Figure 69. Attaching suspenders to tread rope.

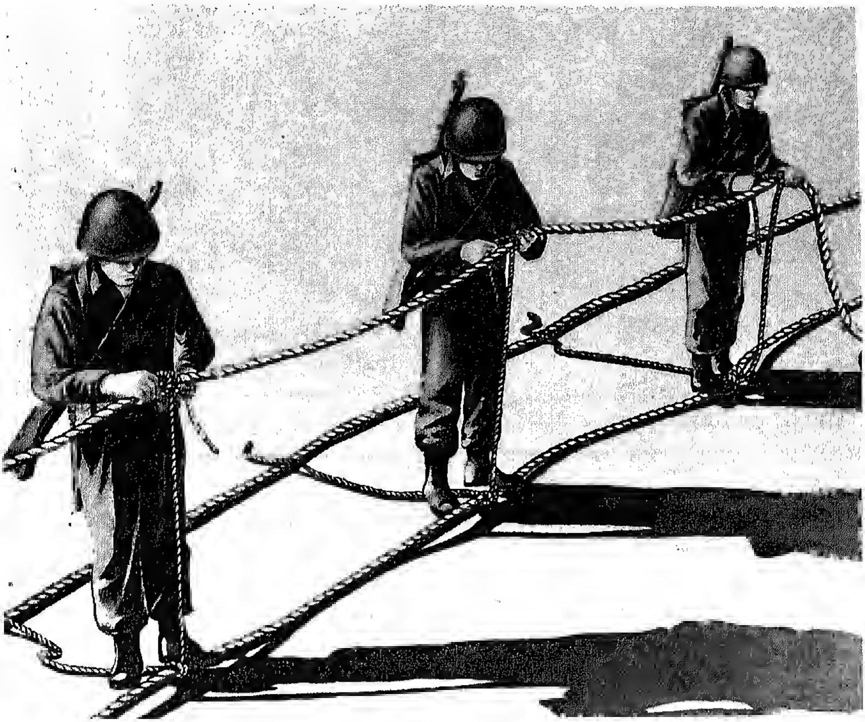


Figure 70. Attaching suspenders to hand ropes.

(6) When the bridge is complete, it is tested to insure that all knots and ties are properly made and suspenders are adjusted. Frequent inspection, adjustment of ties, or tightening of bolts is necessary.

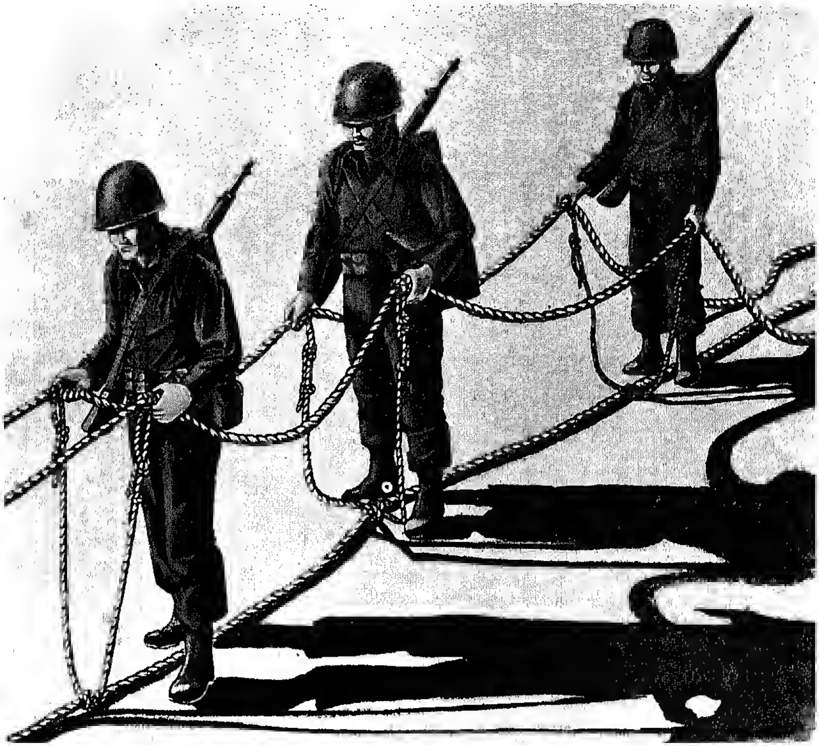


Figure 71. Assembled bridge carried into position.

CHAPTER 6

CASUALTY EVA

Section I. INTF

89. Characteristics

The casualty evacuation quickly rigged simplified Ordinarily it employs gra operated haul lines may b in evacuating casualties, a moving supplies. It can sp up to 200 pounds.

90. Description

A casualty evacuation set consists of a single continuous runs through three snatch blocks, each of which has a handbrak One block is anchored at the higher terminal, from which loads will be moved, and two are anchored at the lower terminal (fig. 72) so that

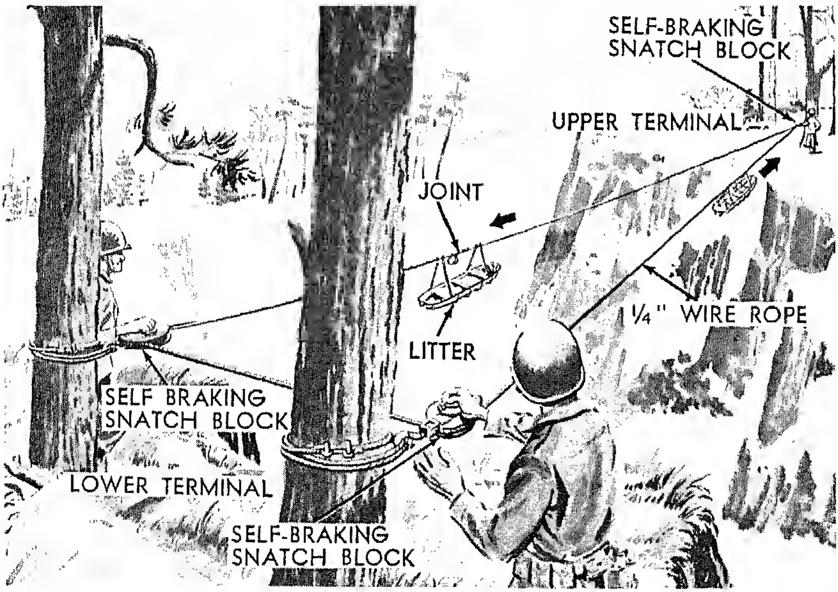


Figure 72. Casualty evacuation set in operation.

the cable forms a triangle. Two Stokes litters for evacuating casualties or two containers for loads are fastened to this cable in such a manner that the container on one leg of the cable is at the lower terminal when the container on the other leg is at the upper terminal. The upper loaded container is permitted to move by gravity to the lower terminal when the brakes on the snatch blocks are released, moving the unloaded container to the upper terminal.

Section II. ERECTION

91. Considerations

Twelve men can erect and adjust a 1,000-foot casualty evacuation set in about 30 minutes if trees are used as anchorages. It may be necessary in some instances to erect shears (para. 96) as a support for one or more blocks to obtain the necessary ground clearance. If trees are not available for anchorage (para. 94), rock anchors or a log deadman may be used.

92. Tools and Equipment

The items of equipment required to rig a casualty evacuation set are listed in table VI. Figure reference numbers in the table refer to figure 73. The tools required in erection are listed in table VII. Figure reference numbers in the table refer to figure 74.

93. Transportation Requirements

The total weight of erection tools and equipment in the issue set for casualty evacuation is 710 pounds. The set occupies 16 cubic feet of space and can be transported on one ¼-ton 4 x 4 truck and one ¼-ton cargo trailer, or two ¼-ton 4 x 4 trucks, or one ¾-ton 4 x 4 cargo truck, or one 2½-ton 6 x 6 cargo truck.

Table VI. Equipment for Casualty Evacuation Set

Reference (fig. 73)	Item	Quantity
2	Block, tackle	5
3	Clip, wire rope	50
4	Hook, hoist	12
5	Litter, rigid, Stokes	4
1	Shield, expansion	10
6	Wire, rope steel	1

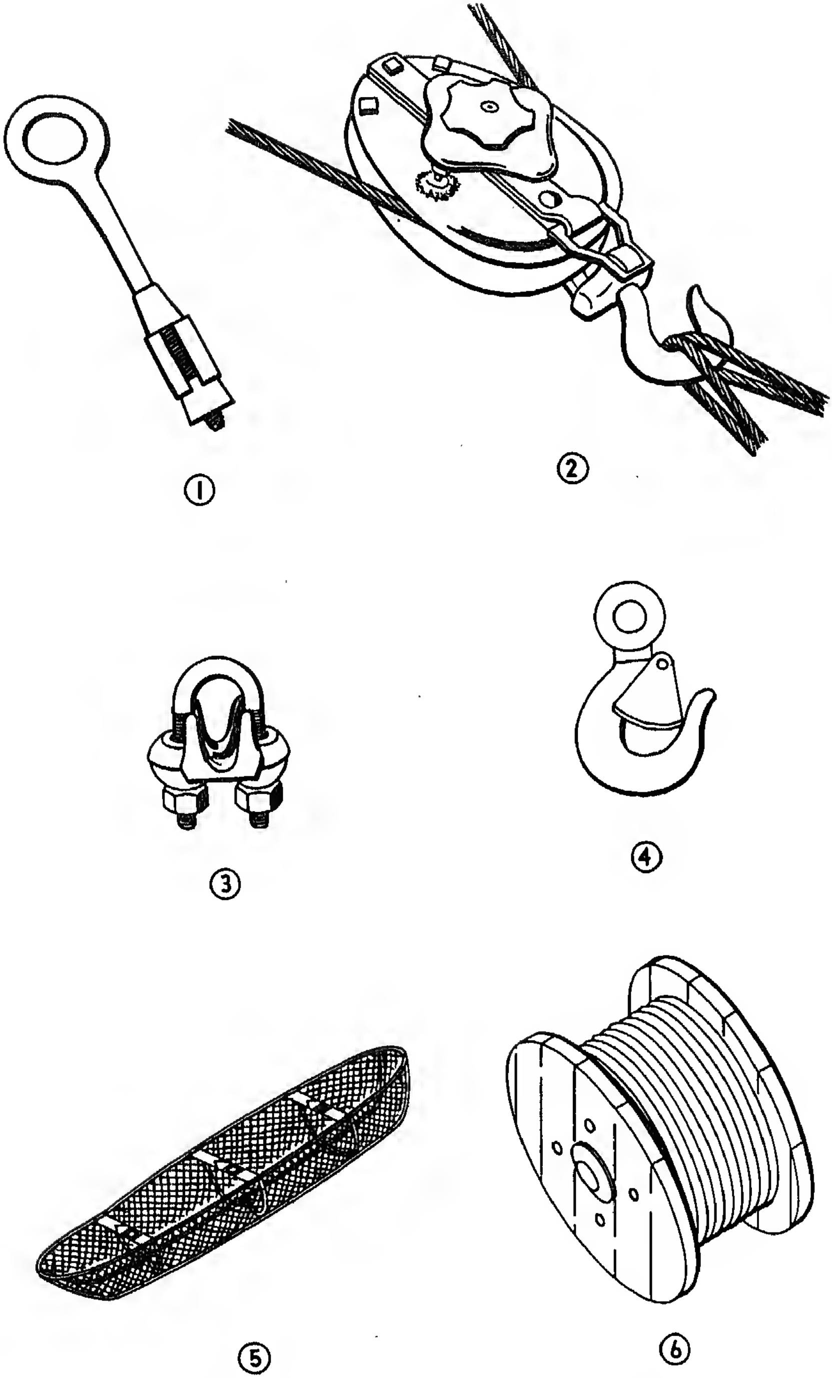


Figure 73. Basic equipment for casualty evacuation set.

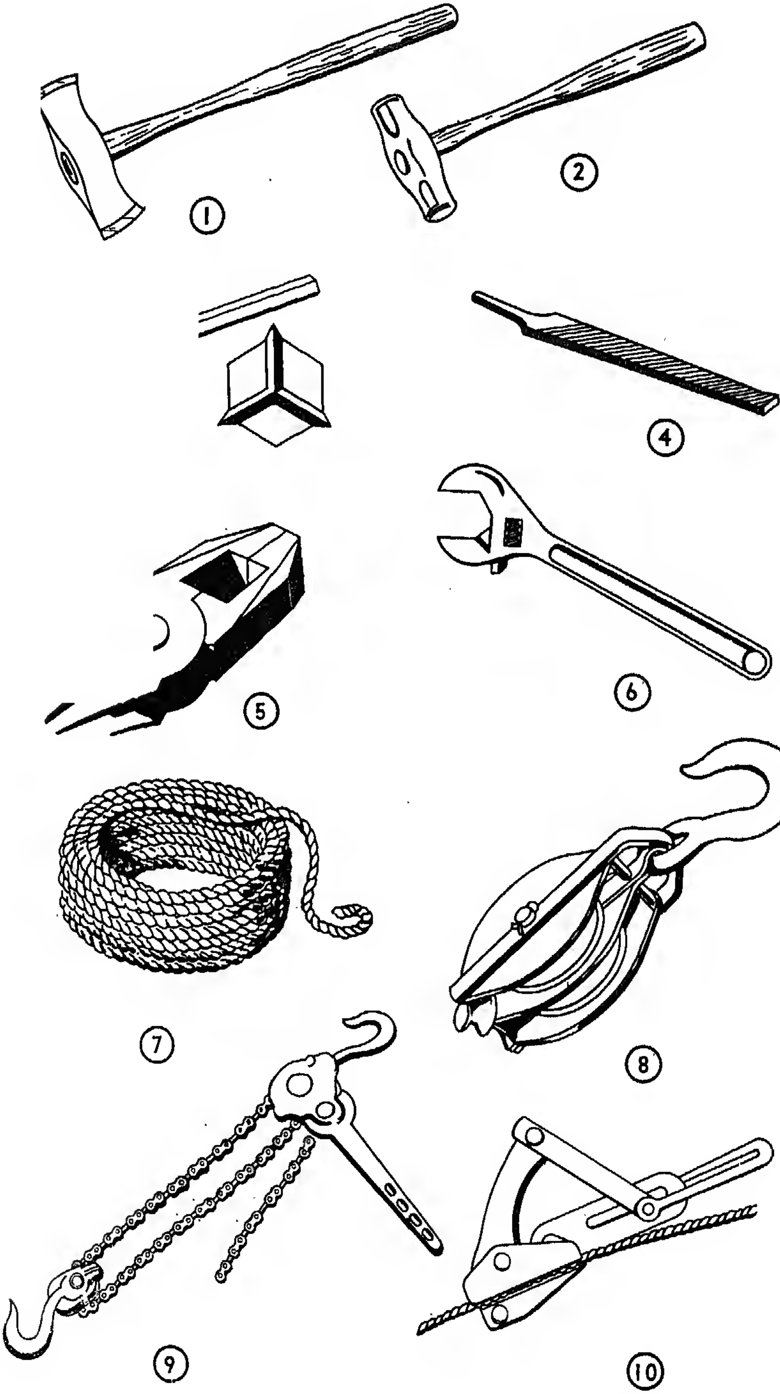


Figure 74. Erection tools for casualty evacuation set.

Table VII. Erection Tools for Casualty Evacuation Set

Reference (fig. 74)	Item	Quantity
1	Ax, double bit	2
8	Block, tackle	2
3	Drill, masonary, hand:	
	¾ in. × 18 in. long	3
	1 in. × 18 in. long	3
4	File, hand	6
10	Grip, cable jaw	4
2	Hammer, hand	2
9	Hoist, chain	1
5	Pliers, lineman's, sidecutter	4
7	Rope, manila	300 ft
	Wire, steel, carbon	1
6	Wrench, open end, adjustable	4

94. Anchorages

Anchorages may be rock anchors, deadmen, or trees. Rock anchors are supplied with the issue equipment and are installed as outlined in paragraph 38. At least two rock anchors are required to hold the upper terminal block and one for each block at the lower terminal. Methods of installing deadmen and other anchorages are discussed in chapter 3. For a deadman, a log at least 5 feet long and 8 inches in diameter, buried 3 feet, will hold any one of the snatch blocks. When a deadman or rock anchors are used, shears are required near the anchorage to raise the snatch blocks on the monocable a minimum of 4 feet to provide ground clearance for the litters. When trees are used for anchorages, they should be at least 12 inches in diameter to make the best anchorages for the blocks. When smaller diameter trees are used, they must be thoroughly braced with guylines. Lash the guylines to the tree just above the slings holding the snatch block and lead them back at an angle of about 45° to the base of a second tree or to a deadman or rock anchor.

95. Rigging

a. Terminals. Select the type of anchorage for each terminal and install them as necessary. Make up slings (para. 97*a*) and fasten the snatch blocks at each terminal.

b. Rigging Cables. Wire rope normally is issued on a reel. Place this reel at the lower terminal on an axle of pipe supported at both ends high enough so the reel clears the ground and is free to turn. A pull on the wire rope will now cause it to unreel without forming kinks. Unreel the wire rope by pulling the free end of it uphill to the upper terminal. Place the wire rope through the snatch block at the upper terminal and pull the free end back downhill. The weight of wire rope

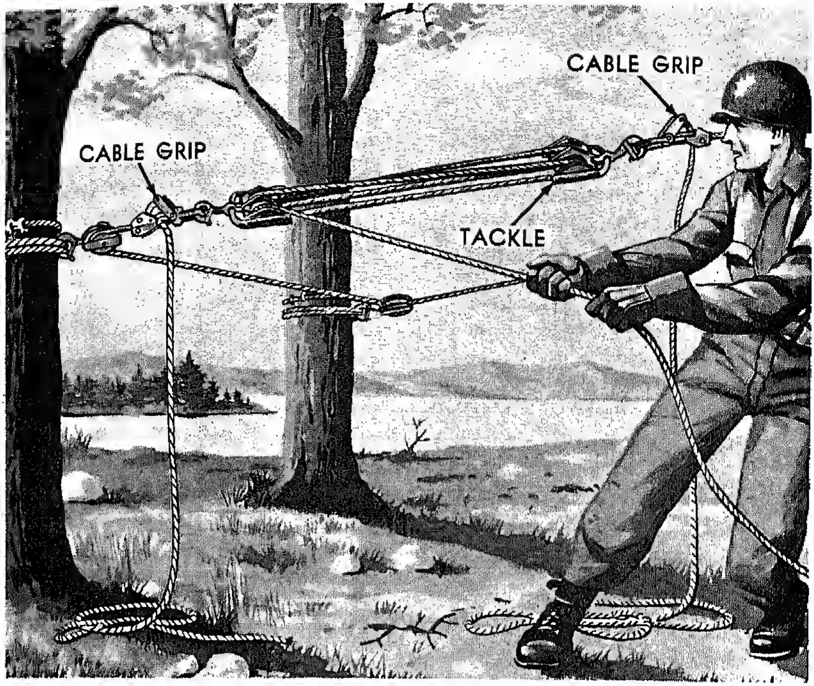


Figure 75. Using tackle to tighten cable.

being moved is less for the uphill move when this system is used. On the downhill pull, the two lengths of rope approach equality in weight as the length of wire pulled through the snatch block becomes greater. If the wire rope is coiled, place the coil upright and roll it along the ground. Unreel or uncoil some additional wire rope at the lower terminal and place this portion of the wire rope in both snatch blocks at the lower terminal. Fasten the two lengths of wire rope together with four wire rope clips just clear of one lower snatch block after tightening to the required sag (*c* below). Fasten one Stokes litter at this point and move it to the upper terminal by pulling the cable through the snatch blocks by hand. Fasten another Stokes litter to the wire rope on the other side of the other lower snatch block ready to move uphill when the first litter moves downhill. This is to prevent the wire rope clips from passing through a snatch block at any time.

c. Tightening Cable. The cable must be tightened to a sag ratio of 6 percent plus 4 feet. This means that the vertical distance from the center of the cable to the chord must be 6 feet for each 100 feet of span length plus an additional 4 feet. In a 1,000-foot installation, this would result in 6 x 10, or 60, plus 4, totalling 64 feet of sag. To install the cable with this sag, measure vertically down from each terminal a distance equal to the amount of sag and make a clear mark.

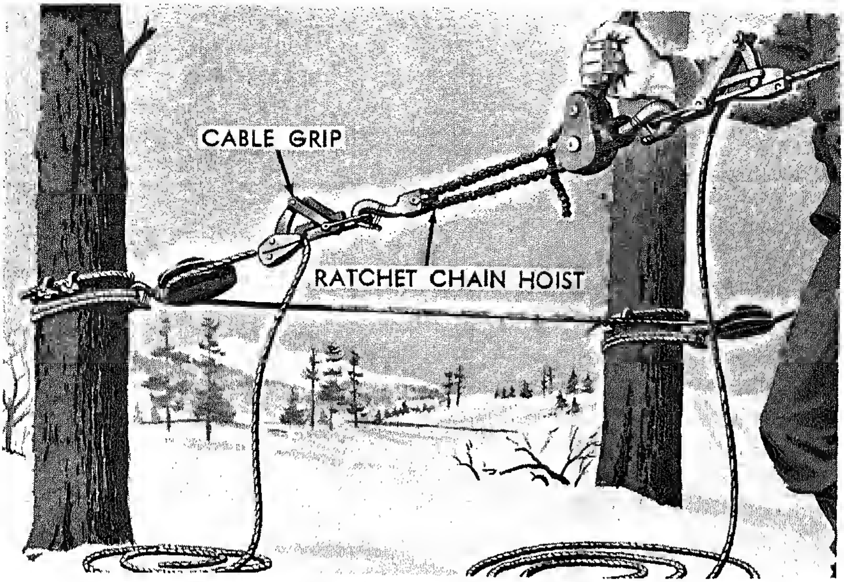
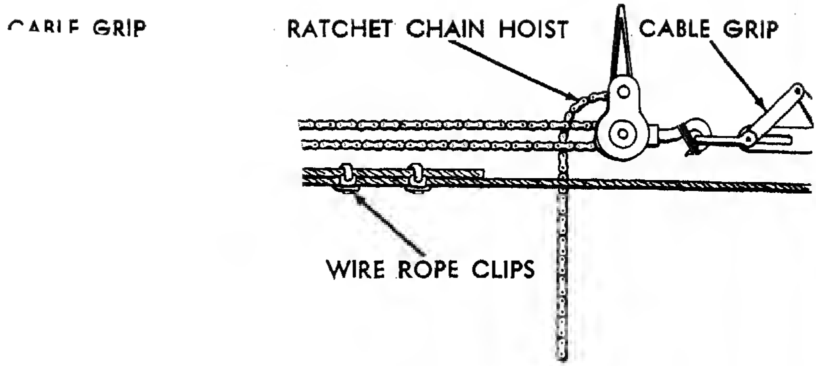


Figure 76. Tightening cable with ratchet chain hoist.

Tighten the cable until the center of the cable is on the line of sight between these two marks. Since a considerable pull is required to achieve this tension, manila rope and two double-sheave blocks are included in the issue kit so that a tackle can be rigged to give the necessary mechanical advantage. Place a cable grip (sometimes called a "come-along" grip) on each piece of wire rope and rig the tackle between them (fig. 75). If this does not serve to tighten the cable the desired amount, place three wire rope clips on the cable to fasten the ends together temporarily, loosen and remove the tackle. Insert the hooks of the ratchet chain hoist in the cable grips, tighten the chain hoist, and remove the three temporary wire rope clips. Using the ratchet chain hoist (fig. 76), tighten the cable until the required sag is obtained. Place the free ends of cable together so they overlap and place four wire rope clips over the two cables with the saddles over the long or continuous end to avoid butting into the cable. Tighten the nuts on the wire rope clips securely (fig. 77). Coil any excess wire rope tightly and bind it to the cable at the point where the wire rope clips fasten the cable together. Slacken the pull on the ratchet chain hoist and remove it and the two cable grips.

96. Shears

Whenever the method of anchoring is such that the snatch block at any terminal would be closer to the ground than 4 feet, rig shears (fig. 78) for that terminal. The method of rigging shears is outlined in TM 5-725. Use poles that are at least 6 inches in diameter and rig



ethod of connecting ends of cable.

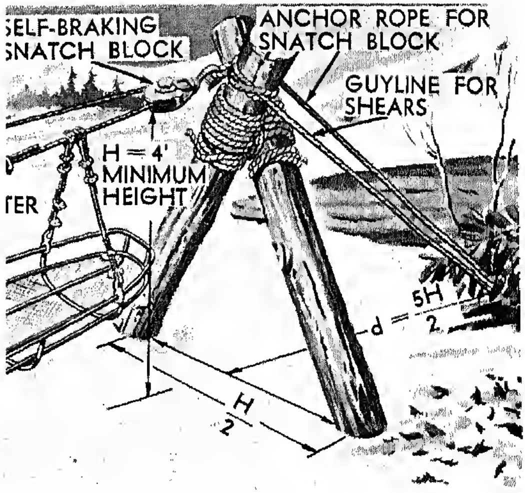


Figure 78. Use of shears to support snatch block at upper terminal.

them to provide dimensions not less than those shown in figure 78. The distance from the shears back to the anchorage should be at least 2½ times the height of the snatch block from the ground. Place a front and back guy from the shears to the anchorage to hold the shears erect. Fasten the snatch block to a separate wire rope over the shears and back to the anchorage so the shears and their guyline will be providing only the vertical support. Always mouse the hook of the snatch block (tie six or eight turns of wire around the open end) to prevent it from slipping off the anchorage cable.

97. Slings and Litters

a. Slings. A double-eye sling can be made up quickly length of wire rope and four wire rope clips. No wire rope thi issued in the set, but such a sling will be stronger if thimbles Place the wire rope on the ground and bend one end of it thimble. Fasten the free end of the wire rope to the star close to the thimble with two wire rope clips and tighten then Place the second thimble in the position necessary to obtain t length of sling and fasten the wire rope about the thimble ir manner as above. Place the wire rope clips so the U-bolt w the short end of the wire rope and the base will bear on th part. A second type of simple sling can be made up by w. wire rope around an anchorage, such as a tree, with one (fig. 79) and two loose loops. Overlap the ends of the wire fasten them together with two wire rope clips. Place the h snatch block through the two loose loops from the top down the hook. This is done to prevent the hook from slipping sling.

b. Litters. Four hanger ropes, each 4 feet long, are used each litter from the main cable. Form an eye at each er hanger rope by looping approximately 6 inches of the free against the standing part. Fasten these ends in place with rope clips at each eye. The eye at one end of each hanger ro

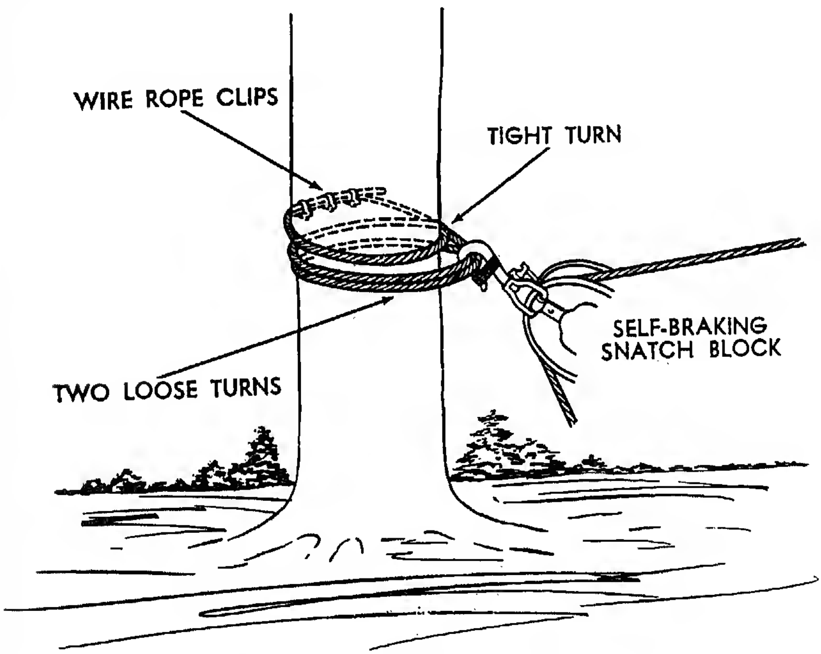


Figure 79. Details of a simple wire rope sling.

made up through the eye of a snap hook, as shown in figure 80. The rope clip is slipped through the other eye and the ·stened securely to the main cable. The wire rope r ropes are placed close together for one end of the ɜr two are placed close together 4 feet from the acing is used to reduce the amount of swing of the ɔkes litter into position after the hanger ropes are ·n cable and hook the four snap hooks into place sure the safety is moved back into place after ··ked. As an alternate method, two 7-foot be used for hangers. An eye is made up ɔok in each end of each rope. A wire rope center of each rope to the main cable, which are attached to the litter as in the

Although the set is designed specifically for supplies or equipment can also be moved over it. ɔf supplies, the packages can be placed in the ·ansported. An expedient load container can be astened to the snap hooks of the hanger ropes in place itter, but no materials for such a load container are he issue set. Rough dimensions for a typical expedient are shown in figure 81.

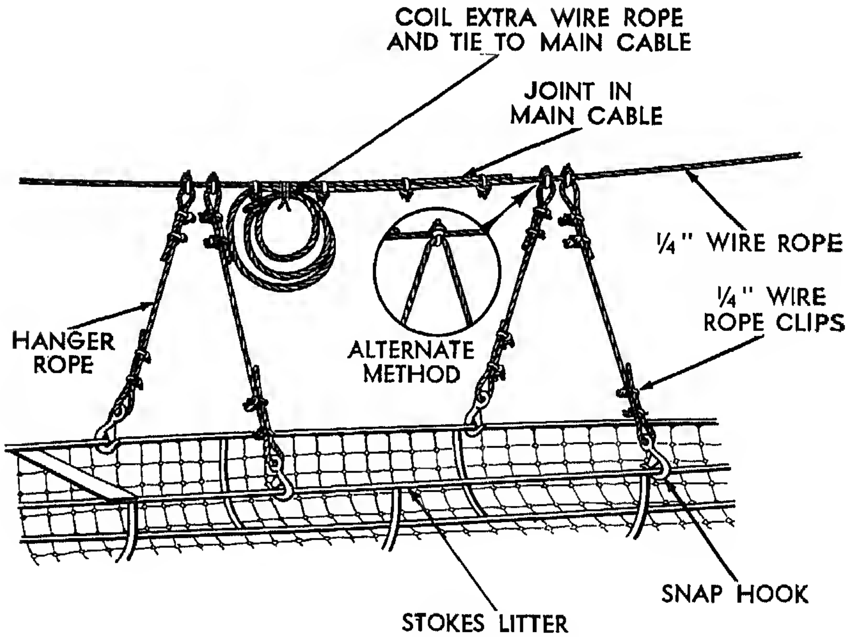


Figure 80. Method of attaching Stokes litter.

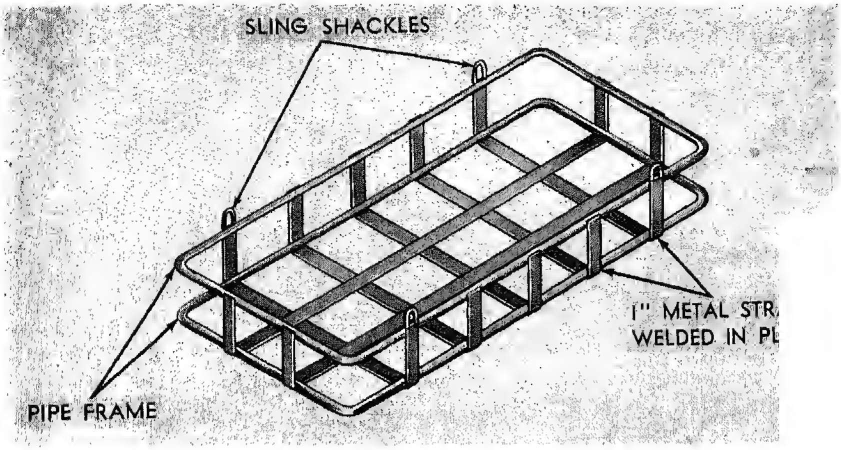


Figure 81. Typical expedient load container.

Section III. OPERATION AND MAINTENANCE

98. Operation

Since the two litters or load containers are firmly fastened t cable, movement of the cable through the snatch blocks will move both litters. The brake control knobs (fig. 82) on the braking snatch blocks are tightened to prevent movement whil containers are being loaded or unloaded. To operate the cas evacuation set, release the brakes on the snatch blocks and pu cable by hand through the blocks until one load container is at the upper terminal and one is at the lower terminal. Set the brakes on the snatch blocks while a load is being placed in the container at the upper terminal. Release the brakes on all three snatch blocks slowly so the weight of the container at the upper terminal will cause it to move to the lower terminal, hauling the unloaded container to the upper terminal. Do not release the brakes fully, as this would permit the load to move too rapidly. Hold the brakes on enough to control the speed of movement of the container.

***Caution:* Always keep all three brakes set fully while loading and unloading the containers.**

99. Haul Lines

The minimum chord slope for the casualty evacuation set is 10 degrees for satisfactory operation by gravity. When the set is operated in flat terrain, it may not be possible to place the upper terminal high enough to obtain the desired slope. In such a case attach a hemp rope (¼-in. to ½-in. diameter) 1,000 feet long to each of the containers. One rope is paid out from the lower terminal as the other rope is hauled in at the same terminal. The speed of

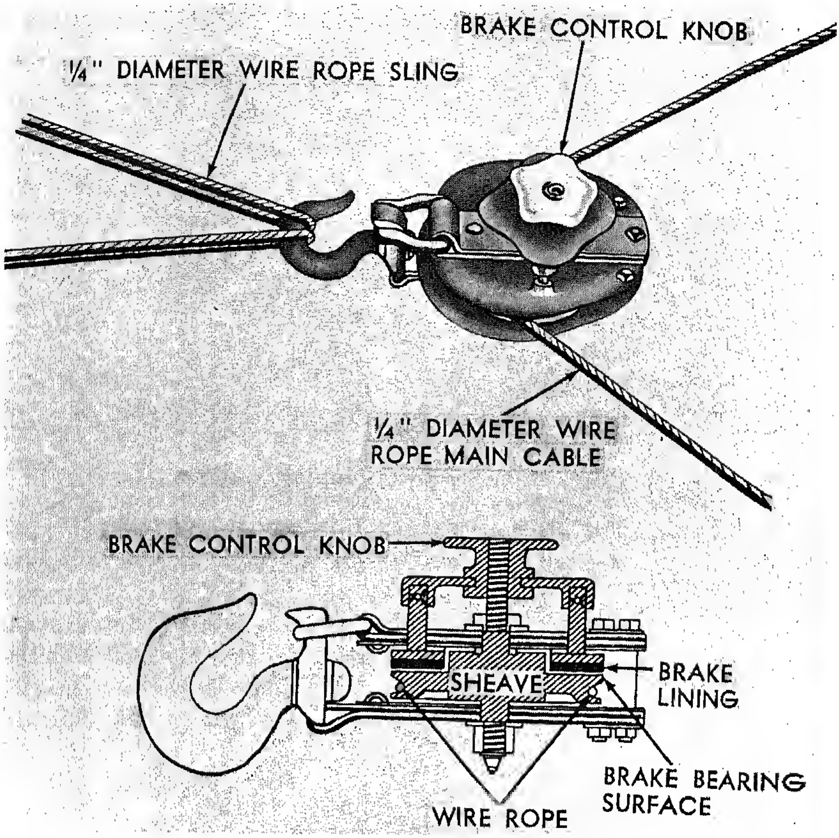


Figure 82. Self-braking snatch block.

movement is still controlled by the brakes on the snatch blocks. The ropes must be carefully coiled as they are hauled in, to prevent snarling when they are paid out on the next trip.

100. Safety Precautions

Correct use of brakes is the key to safe operation of the casualty evacuation set. Do not try to use one brake to control the operation; use all three brakes equally. To protect the brakes and the load, avoid surges of motion and sudden stops. Never permit the load to move rapidly, as the brakes will be subjected to greater wear in stopping a rapidly moving load. Strap casualties securely in litters and check all safety hooks on litter hanger ropes to be certain they are snapped in place. Do not place loads in excess of 200 pounds in the load containers, as this is the maximum design load. Lubricate all snatch blocks frequently, preferably after every two or three trips of the litters, to maintain constant smooth operation.

CHAP

PIONEER LIGHT AERIA

Sectio

101. Characteristics

The pioneer light M1
Erected as a tramway, it h
operate on slopes up to 3
350 pounds and can opera
a cableway, it has maxim
slopes up to 30°. It will
maximum speed of 500 f
between this and the M2 set (ch. 8) ...
a minimum of issue equipment, relying on c
other components from native material, whi...
components prefabricated.

102. Equipment

The items of equipment included in the pioneer light aerial tramway and cableway set are listed in table VIII. Some of these components are shown in figure 84.

103. Description

a. General Design. The set includes track cable, a carriage, a carrier, a power unit, a tobogan, haul rope, and track cable hangers. No towers or tower parts are included, and the components can be assembled in one of three ways described below:

(1) Using native materials for terminals and intermediate towers, a tramway can be constructed. The track cable is fixed in place and the carriage is hauled back and forth by a haul rope attached to the power unit (fig. 83). The terrain may have any number of variations. The intermediate towers can be placed to match the terrain. The chord slope between any two towers must not exceed 40°. Maximum net payload is 350 pounds. Maximum length is 2,000 feet.

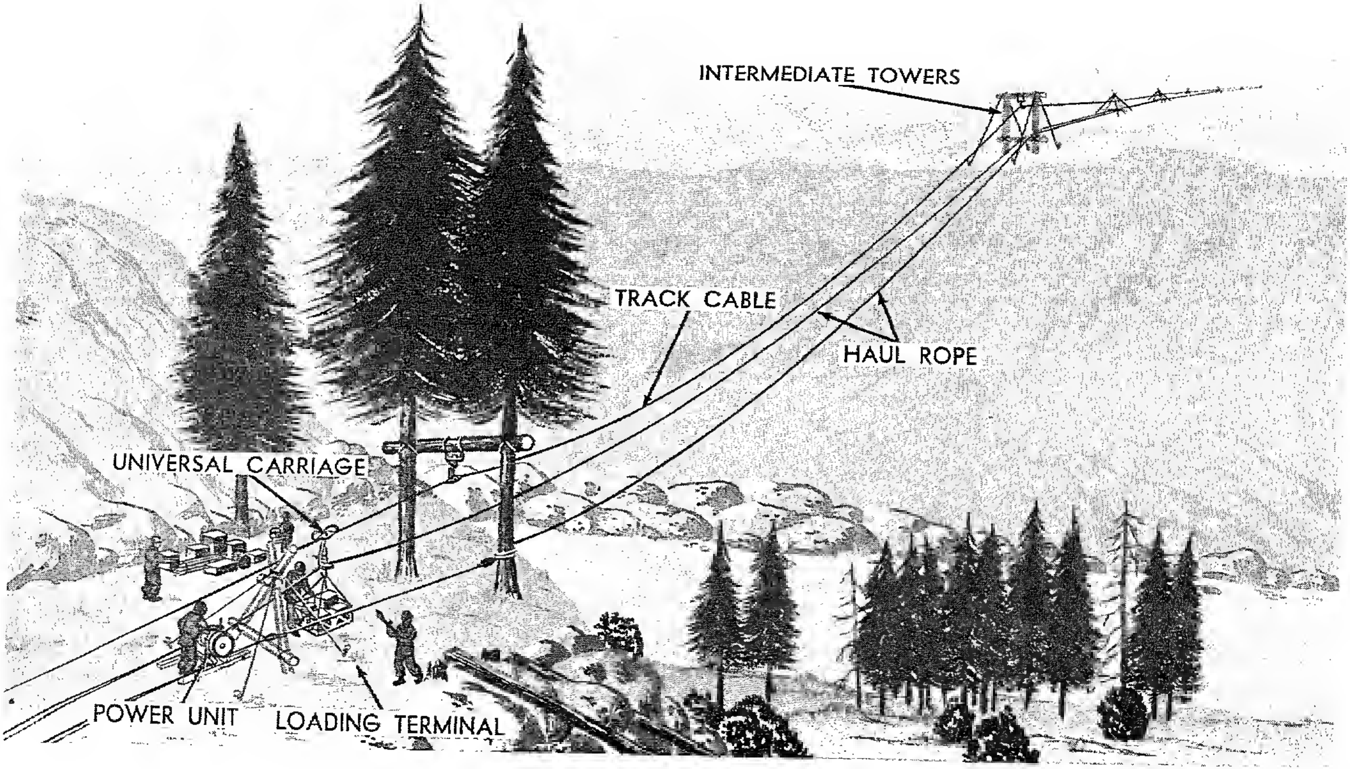


Figure 83. Features of the pioneer light aerial tramway set, M1.

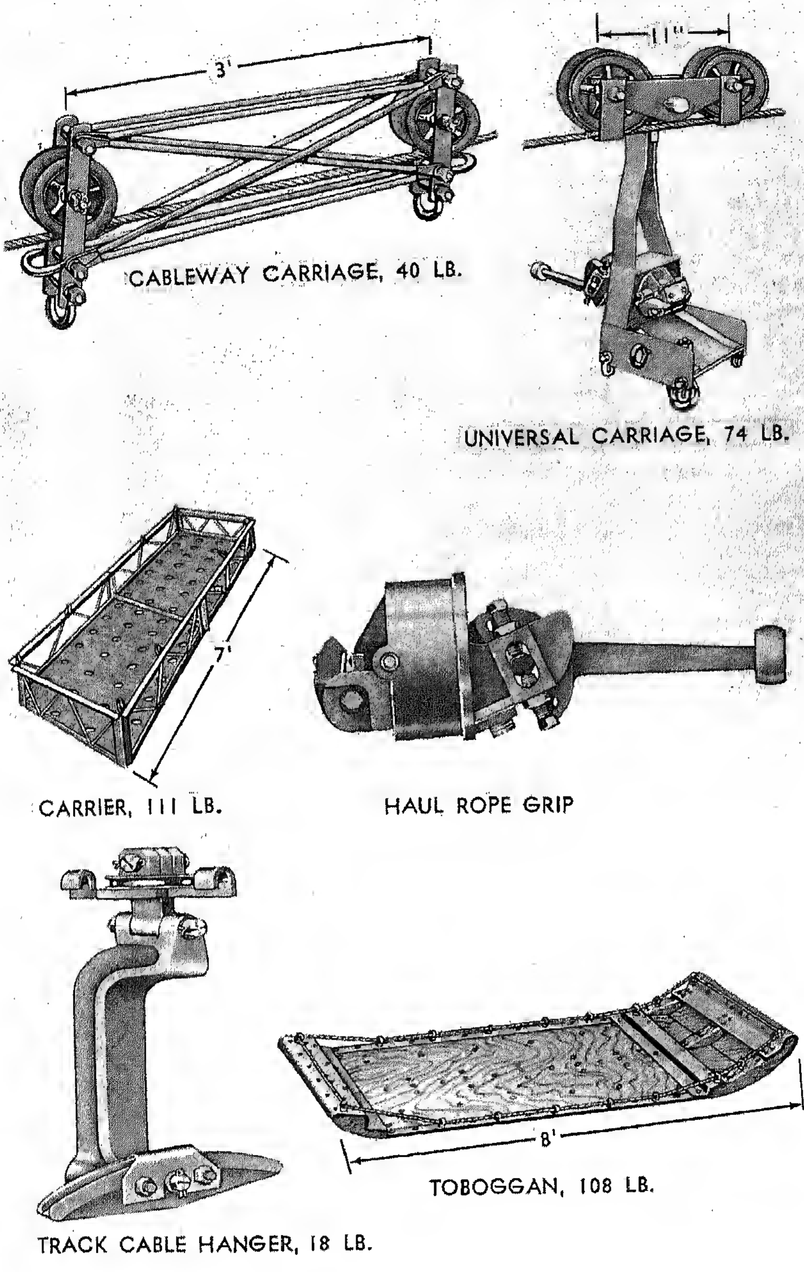


Figure 84. Components of pioneer light aerial tramway, M1.

Table VIII. Equipment for Pioneer Light Aerial Tramway and Cableway M1

Item	Quantity
	12
	1
	6
	3
	400
	150
cableway	1
	6
	15
	24
	1
	25
	50
	2
ow steel:	
	8,000 ft
	3,000 ft

materials for terminals, a cableway can be There are no intermediate towers and erection r. Cableway installations are satisfactory for ng a single deep gorge or a stream (fig. 85). The net ad can be greater, up to 2,000 pounds, because of the er erection sag, which reduces the tension in the track cable. The track cable for a cableway is fixed in place and the carriage is hauled back and forth py a haul rope attached to the power unit.

(3) Using trees or terminals of native materials, the power unit and haul rope can be rigged without the track cable to pull a toboggan (fig. 86) as a toboggan hauling unit. The toboggan can be used on snow or smooth ground and is quickly and easily rigged. It can be used to transport materials and equipment for erection of a more permanent installation or to transport supplies temporarily while a more permanent installation is being made.

b. Towers. All towers are improvised in the field. Standing trees may be used (fig. 87) or the towers may be constructed of timbers cut at the site. At installations where there is a natural anchorage almost immediately behind and 10 to 12 feet above the power unit, a loading terminal tower need not be erected if an intermediate tower is used a short distance ahead of the power unit.

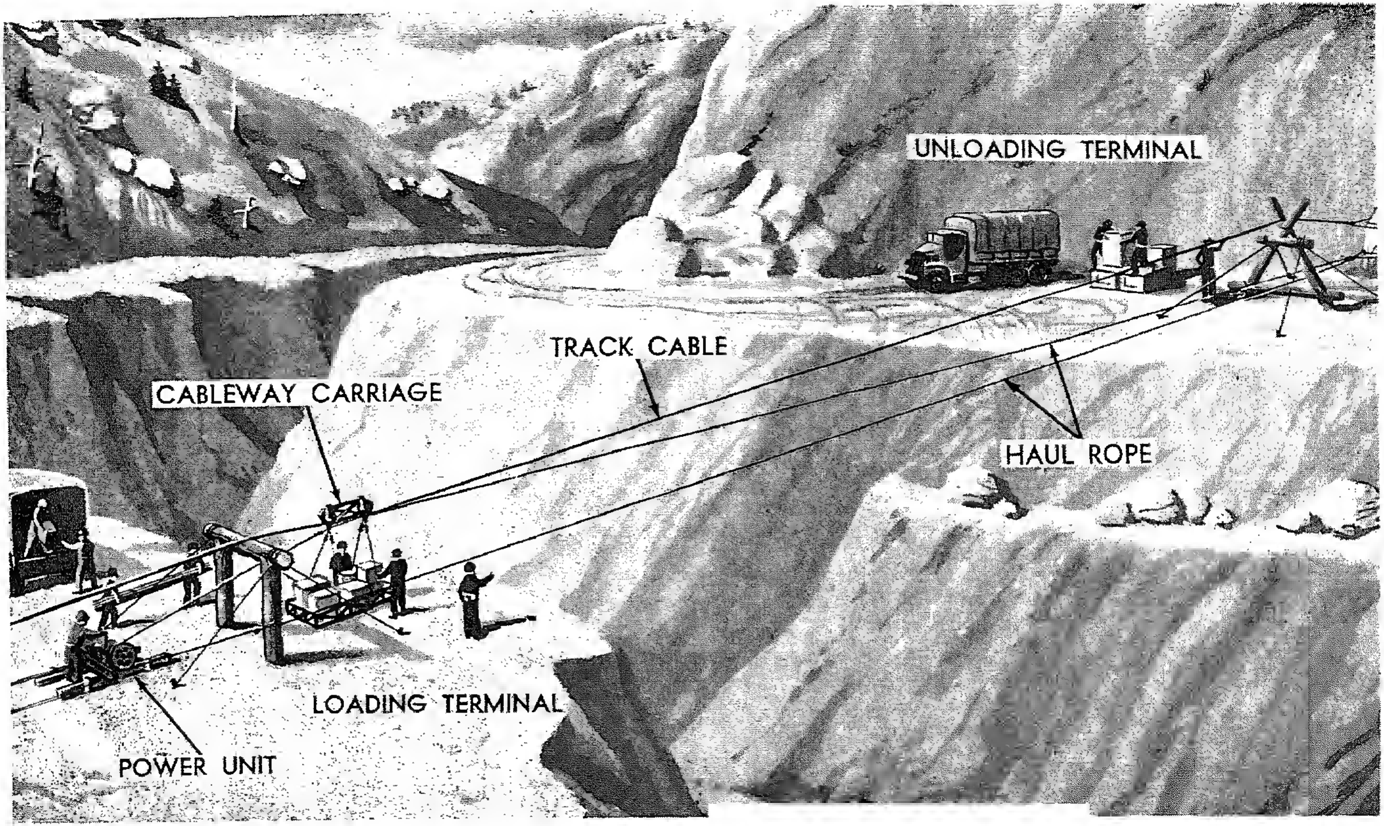


Figure 85. Features of a lin

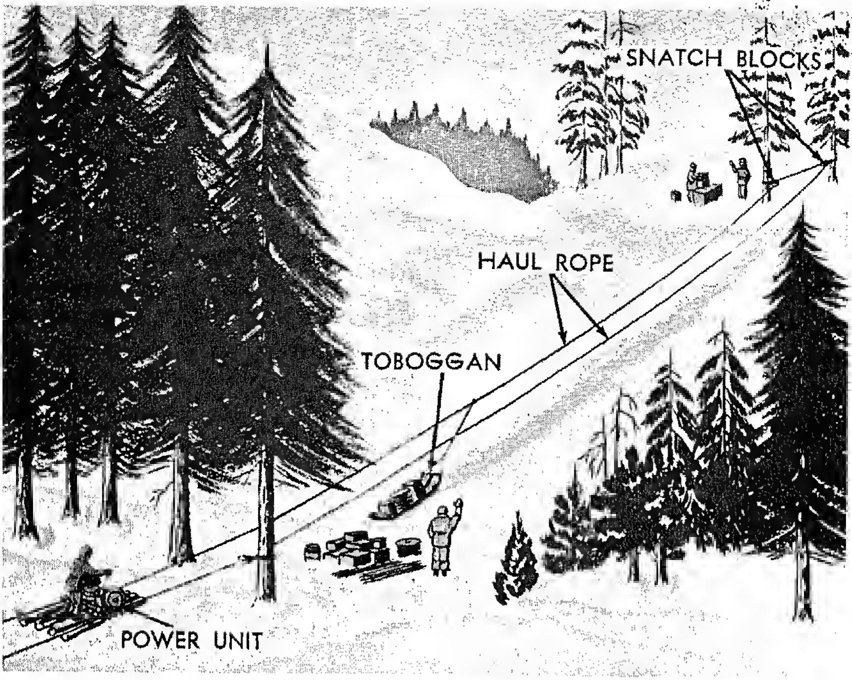
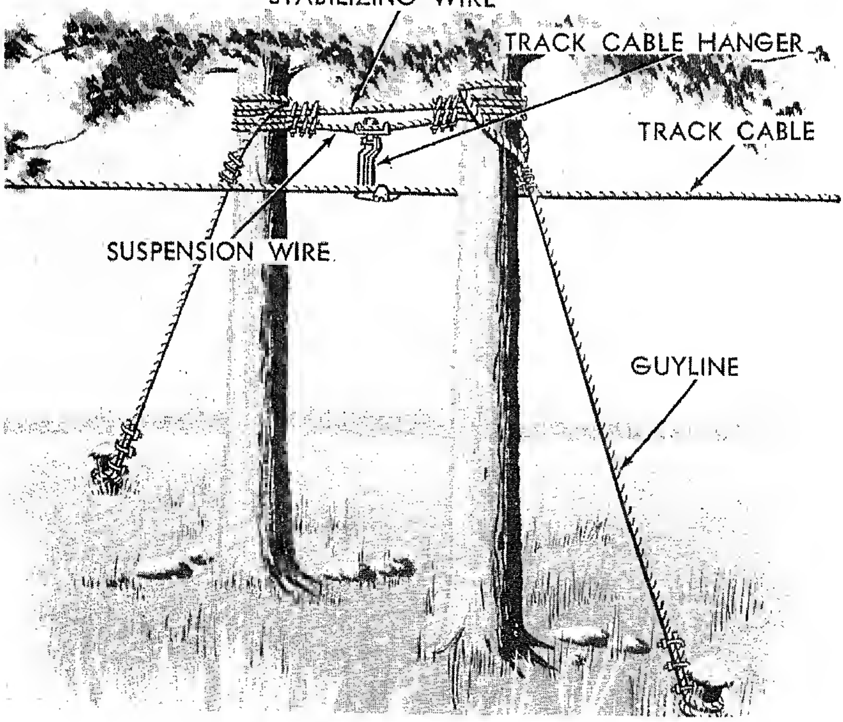


Figure 86. Features of a toboggan hauling unit.



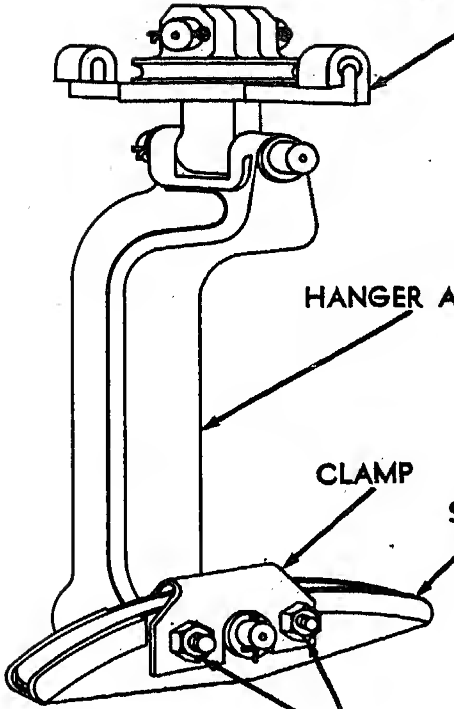


Figure 88. Track cable hanger.

c. Track Cable. A single track cable 3,000 feet long of ½-inch 6 x 19 wire rope is used. It is included in the set, and is strung in a straight line for the full length of the cableway or tramway.

The ends of the track cable are anchored at the two terminals. In a tramway installation, the track cable is supported at each intermediate tower by a track cable hanger (fig. 88).

d. Haul Rope. A haul rope of ¼-inch diameter, 6 x 7 wire rope 8,000 feet long is included in the set. The haul rope is rigged to be continuous by reeving it through one or more snatch blocks at the unloading terminal. Only about 4,000 to 4,200 feet of haul rope is required for the longest single installation, and the excess is used for guylines and anchorage slings.

e. Carriage. Two carriages are supplied in the set. The cableway carriage (fig. 89) has a pipe framework and is supported on the track cable by two 6-inch diameter sheaves. The track cable passes through the framework so the carriage cannot jump off the cable. Because of this it cannot be used in a tramway installation, as the framework could not pass a track cable hanger at an intermediate tower. A

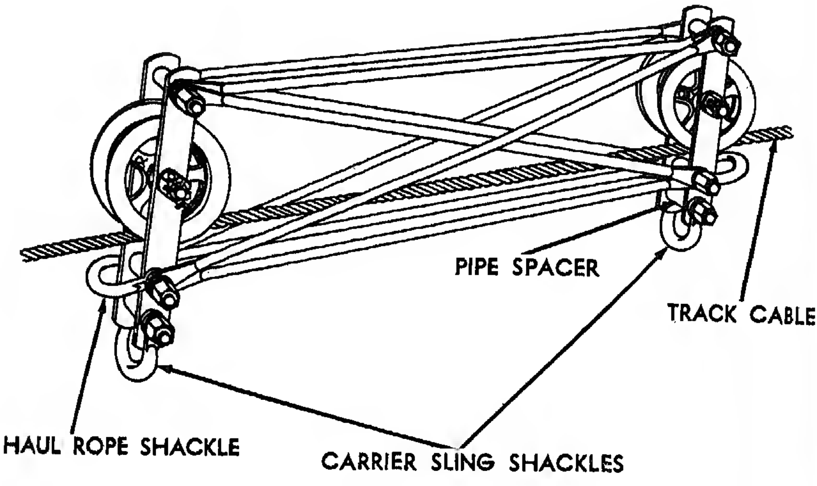


Figure 89. Cableway carriage.

universal carriage (fig. 90) is supplied for use in a tramway installation. By attaching two removable guards this carriage can also be used on a cableway.

f. Carrier. Loads such as pipe can be slung directly beneath either carriage (*e* above). For personnel and packaged materials, a carrier is slung below the carriage. The basic carrier is a steel plate 3½-feet long (fig. 91) perforated and provided with an angle frame. End and side frames can be added to this plate to make up a complete carrier (fig. 92). The end and side frames are made of angle iron and steel rods. Two such carriers bolted together without the end frames at the point of joining (fig. 93) make a 7-foot carrier for larger loads. Enough equipment is furnished in the set to construct six of the short carriers or three of the longer carriers.

g. Toboggan. A toboggan 8 feet long made of plywood with wood reinforcing (fig. 94) is included in the set for use in constructing a toboggan hauling unit. The bottom and the three plywood skids are sheathed with metal to protect the toboggan on bare ground. Eyebolts are provided for lashing loads and for attaching a hauling bridle.

h. Power Unit. The power unit operates the continuous haul rope to move the carriage or toboggan back and forth. A power unit has been developed for use with the M1 and M2 light aerial tramways and the medium cableway. It is an enclosed skid-mounted gasoline-engine-driven unit delivering 20 hp at the drive spool at a crankshaft speed of 2,250 rpm (Continental Model SF–162) complete with an industrial clutch, muffler, radiator and head. A double universal with slip propeller shaft drives a heavy duty industrial type transmission with a forward and reverse drive ratio of 40 to 1. A drive spool for the haul rope is located on the output shaft at the rear end of the

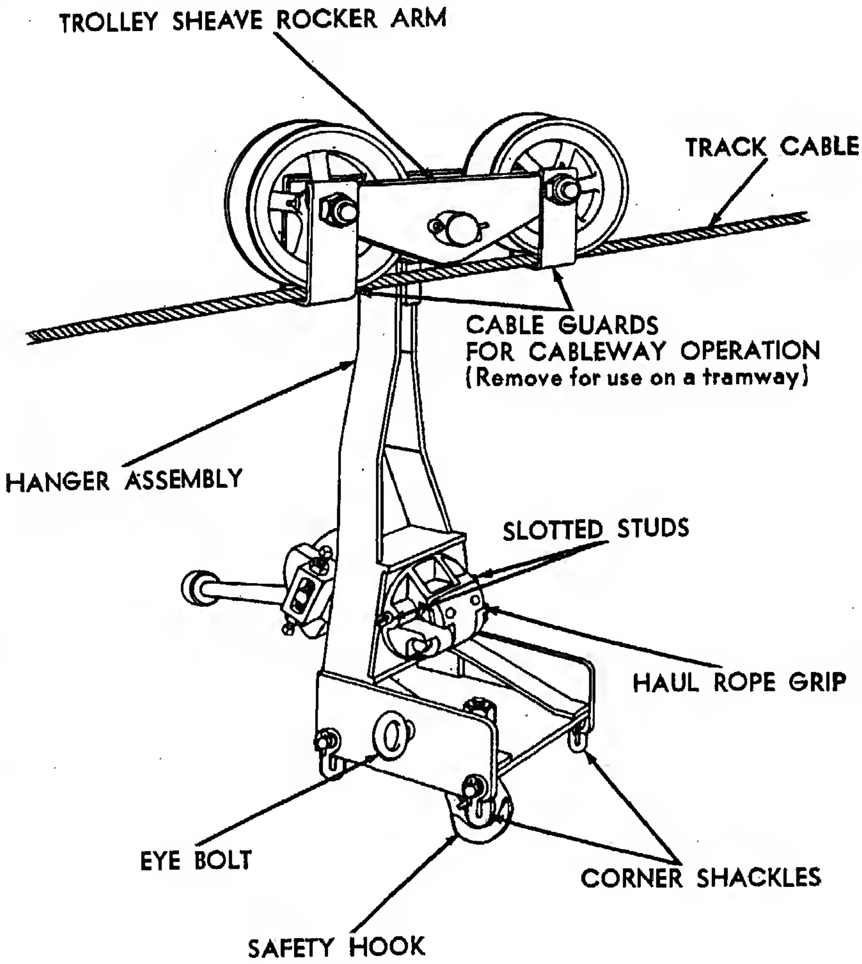


Figure 90. Universal carriage.

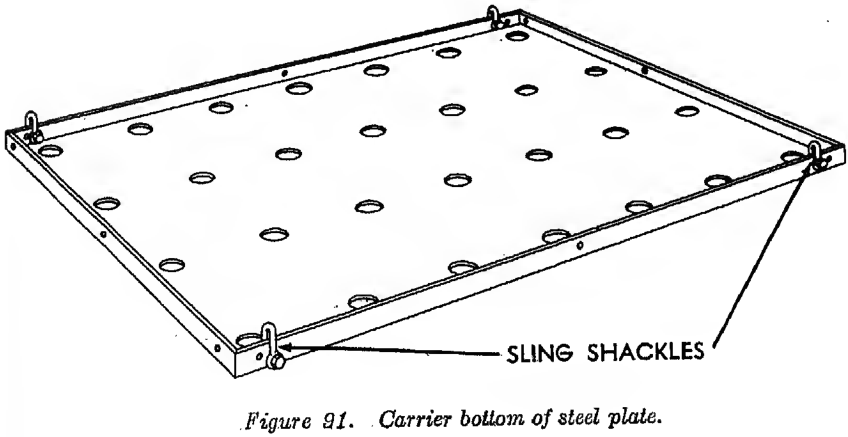


Figure 91. Carrier bottom of steel plate.

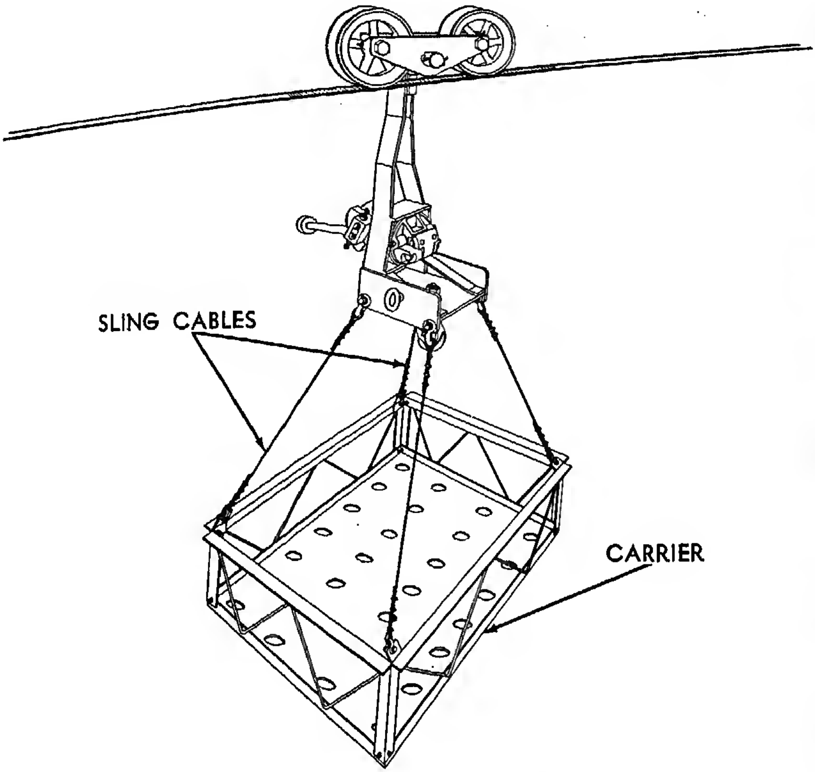


Figure 92. Short carrier beneath universal carriage.

unit. The power unit is operated in forward or reverse drive to move the carriage in the desired direction. Detailed operation and maintenance instructions for this power unit are covered in a separate technical manual, TM 5–9157.

i. Rigging Accessories. Rigging accessories are supplied with the set. This is particularly important in installing the track cable anchorage at the power unit terminal, since erection sag must be precisely set. Double sheave blocks and a ratchet chain hoist (fig. 95) are provided, together with cable grips, to apply the necessary tension in the cable. A tensiometer is provided to indicate the amount of tension.

104. Transportation

The pioneer light aerial tramway and cableway M1 can be transported on one 2½-ton 6 x 6 cargo truck, or four ¾-ton 4 x 4 cargo trucks, it should be so arranged on the truck that the power unit, haul rope, and toboggan are easily accessible since they may be needed first when the site is reached.

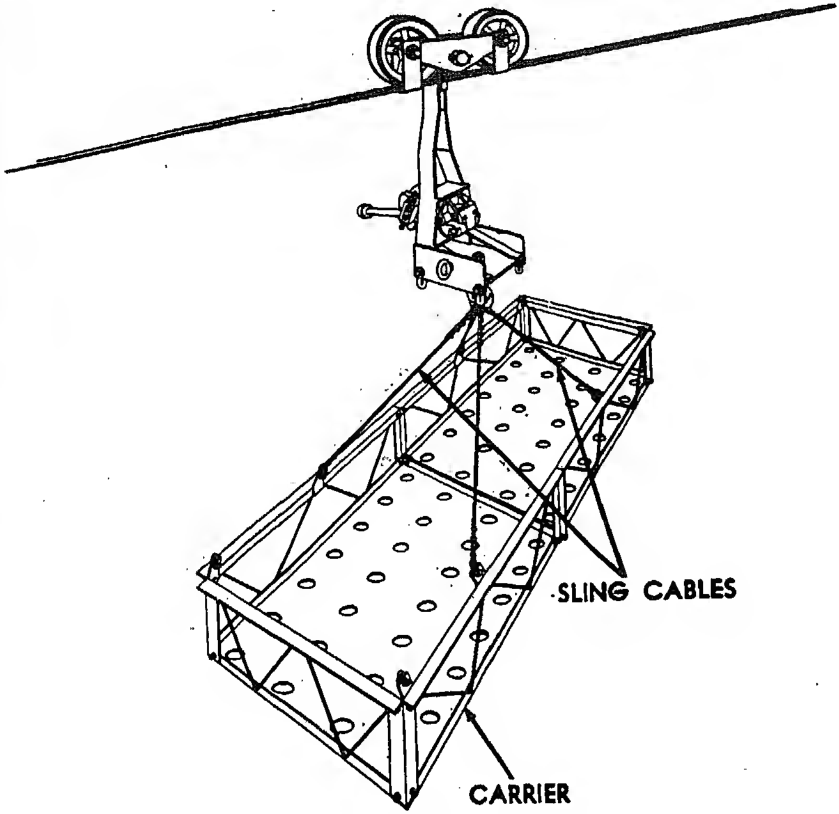


Figure 93. Long carrier slung beneath universal carriage.

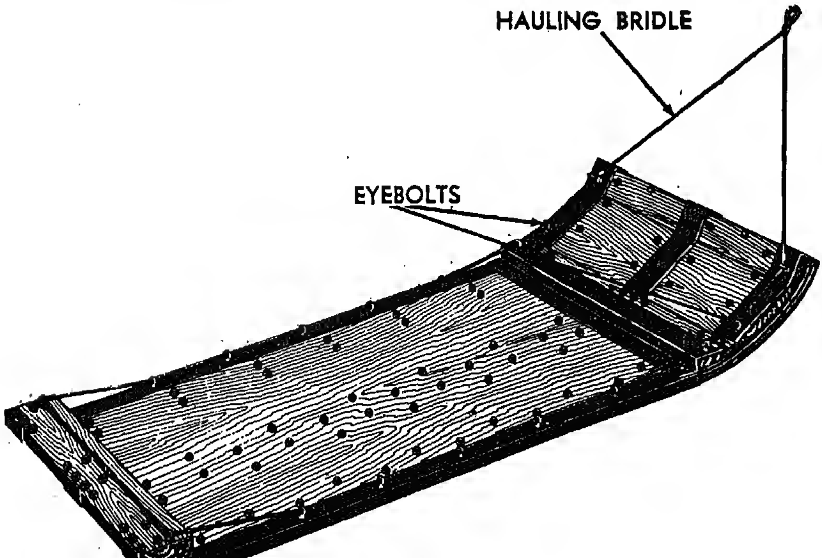


Figure 94. Toboggan.

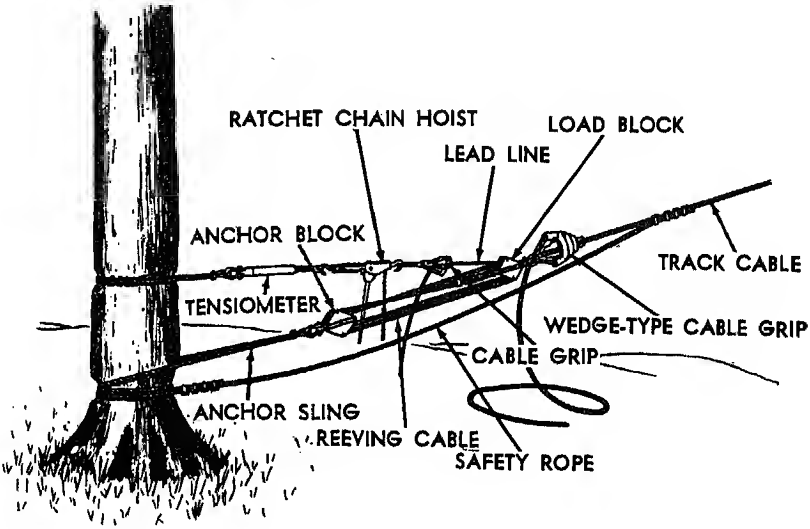


Figure 95. Method of obtaining correct track cable erection sag.

Section II. ERECTION PROCEDURE

105. Considerations

After the site is selected it must be surveyed to determine whether the set is to be erected as a tramway or a cableway and what towers ...quired if a tramway is to be used. The working party and erection tools must be placed at the site so that the various parts of the installation reach completion in a sequential manner. This section will deal only with these phases of erection. Tower construction is covered in paragraphs 22 through 29. Installation of components is covered in a later section of this chapter.

106. Site Requirements

A visual survey of the general area should be made before the actual site is selected. Accessibility of the loading terminal and unloading terminal is a prime requisite. Maximum length between terminals must not exceed 2,000 feet for a tramway or 1,500 feet if a cableway is to be used. When the required length of haul exceeds the maximum length of the tramway, two tramways can be used in tandem. In such a case, place the unloading terminal of the first tramway adjacent to the loading terminal of the second tramway to minimize the handling required in transferring loads at this point. The terminals and intermediate towers in a tramway must lie in a straight line. Availability of natural anchorages, such as trees or rocks, and timber from which materials for towers can be cut are very important. If circumstances require that the installation be made above the timberline, there must be a trail available over which the necessary timbers

can be transported. Concave surfaces of great width must be avoided, since there is no provision in the set for holding down the track cable at intermediate towers, and towers of sufficient height to avoid this are difficult to build from native materials. Sharp crests should be avoided, as the maximum deflection angle of the track cable over a saddle at an intermediate tower is 10°. In measuring the deflection angle (fig. 96), remember that the chord line is a straight line between two adjacent saddles, while the actual track cable sags below this line. The deflection angle is therefore the angle made by two chord lines. Chord slope between any two towers must not exceed 40° from the horizontal.

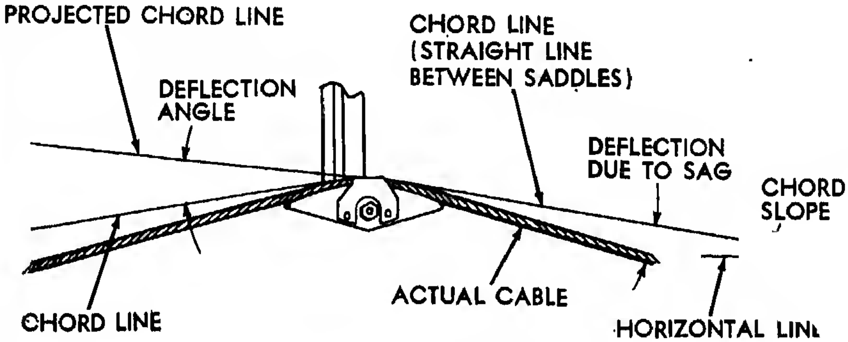


Figure 96. Track cable deflection at saddle and slope.

107. Survey

After the site has been selected it must be surveyed. Two or more transits are desirable. Locate one terminal and set up one transit there. Locate the other terminal and establish the centerline of the installation on the ground. Use the first transit to keep the other transit in line and make a stadia survey of the terrain between terminals. From this survey draw up a profile to a convenient scale of the centerline. From this profile a determination can be reached whether to erect a cableway or tramway. Tower locations and heights for a tramway may be determined directly from the profile. Intermediate towers in a tramway are intended to provide sufficient ground clearance for loaded carriers and they are therefore placed at high points of the profile that would otherwise interfere with carrier movements.

108. Working Party

The working party must be subdivided into groups and each group assigned to one phase of the operation so that all phases can progress concurrently. For cableway erection one group should be assigned to each terminal and a third group should be assigned for clearing and cutting timbers. The terminal construction groups are further sub-

divided so that one party is erecting the tower, a second party is preparing anchorages, and a third party is rigging the components. n will apply for tramway construction except that ɒ should be set up and assigned to construction ɜ tower. Information is provided to each group ı as to tower height. The transit is in constant ramway centerline.

should progress simultaneously with the cutting ɔr tower and terminal erection to minimize the Before clearing starts, mark those trees which are for use in towers or as anchorages. The clearing one in a manner that will leave the finished instal-ɔuous from the air as possible. If it is feasible, for construction should be scattered for this same

ools

should be distributed to the various working loca-r that will expedite the construction. Tools supplied ted in table IX.

X. *Erection Tools for Tramway and Cableway Set M1*

Item	Quantity
x, double bit	6
Battery dry	18
Belt, safety, industrial:	
36-in. waist	5
40-in. waist	6
42-in. waist	5
Bit, auger:	
¼-in. dia	2
⅜-in. dia	2
½-in. dia	2
Blade, hand hacksaw	144
Block, tackle:	
¾-ton, ¾-in. fiber rope	2
3-ton, ½-in. wire rope	4
Bolt, machine	100
Brace, bit, ratchet	3
Cable, telephone	1
Chisel, cold, hand	6
Climbers set, tree and pole	11
Crowbar	3
Drill, masonary, hand:	
¾-in., 18 in. lg	8
1-in., 18 in. lg	8

Table IX. Erection Tools for Tramway and Cableway Set M1—Continued

Item	Quantity
File, hand	24
Frame, hand hacksaw	2
Grinding machine, bench, hand operator	
Grip, cable, jaw:	
Parallel	
Wedge and roller	
Hammer, hand:	
Carpenters	
Striking, drilling	
Hoist, chain	
Insulation tape: electrical:	
Cotton	
Rubber	
Marlinspike	
Mattock	
Nail, common:	
30d	
60d	
Peavy	
Pipe, steel	
Pliers	
Rope, manila	
Safety can, fuel	
Saw, cross cut, two man	
Saw, hand, crosscut	
Screwdriver flat tip	3
Shovel, hand, D handle:	
Round point	6
Square point	6
Stone, sharpening	4
Strap, safety, industrial	16
Telephone set, field type	3
Tool box, portable	2
Winch, drum, hand operated	1
Wire, steel, carbon	5
Wire rope, steel	1
Wrench, open end, adjustable	24

Section III. INSTALLATION

111. Procedure

When all towers have been constructed (paras. 22 through 29) the cableway or tramway is ready for final installation. Anchorages must be prepared for the track cable at both terminals and takeup gear rigged for the track cable and power unit. The power unit is then set in position and the haul rope is rigged. The haul rope is used to pull the track cable into place. The carriage and carrier are installed on the track cable and the installation is complete. Procedure

is the same for tramway or cableway erection except that the cableway does not use intermediate towers.

112. Anchorages

An anchorage is required at the upper terminal for the track cable end. At the lower terminal and anchorage and takeup gear is required for the track cable end. An anchorage is also required for the sling to the power unit. Both of these can sometimes be attached to the same anchorage. A standing tree or sound stump 18 inches or more in diameter makes the most satisfactory anchorage for the track cable because it is easier to rig the three separate slings required. If the terminal tower is built of standing trees which can be securely braced against other trees, the track cable anchorage can be as much as 15° out of line with the line of the track cable. If timber towers are used, this is not desirable construction. A timber deadman can be used for an anchorage but will require three slings for the track cable and one for the power unit. Separate deadman anchorages for the power unit and track cable are more satisfactory. Construction of a deadman is outlined in chapter 3 of this manual and further information can be found in TM 5–725. The anchorage slings should be made up of ½-inch diameter wire rope securely fastened with three or four wire rope clips.

113. Power Unit

The power unit is usually placed at the lower terminal, and is anchored in such a manner that it can be used to take up slack in the haul rope. The power unit should set level. If the position selected for it is rough or uneven, it must be leveled. Select two timbers, such as 6 x 6 lumber or squared logs, about 10 feet long. Place them on the leveled ground parallel to each other and to the direction of the track cable. The timbers should be spaced so that when the power unit is placed on them the skids of the power unit will extend about 10 inches at each end and the drive spool will be halfway between the track cable and the return side of the haul rope. Cut several stakes from 3-inch diameter material about 2 feet long and drive them so as to hold the timber skids in place. The stakes should not project above the top of the skids. After driving the stakes, drill through the skids and stakes and bolt them together with ¾-inch machine bolts 12 inches long. Set the power unit across the wooden skids so that the drive spool rotates in a direction parallel to the track cable. The power unit should be at the end of the wooden skids nearest the terminal tower when first set in place. Hook a ratchet chain hoist in the sling of the anchorage. Make up two slings of ¼-inch diameter wire rope with wire rope clips. These two slings should be just long enough so that one end of each is fastened to the power unit skids (fig. 24) and the other end is hooked to the fully

extended ratchet chain hoist. This anchorage can be used to take up the slack in the haul rope after it is installed by pulling the power unit away from the terminal tower.

114. Erecting Haul Rope

a. Procedure. The haul rope must be installed to form a continuous loop so that when it is moved by the power unit it will pull the carriage back and forth. The haul rope is erected in the same manner for a cableway or tramway installation except that for a tramway it must pass through the intermediate towers. In the finished installation there will be two parts to the haul rope as it passes through these towers. One side must be kept clear, since it will be pulling the carriage back and forth. The other side, which is called the return side, can be supported at the towers by snatch blocks without interfering with carriage movement. The return side is erected first so the snatch blocks can be used to lighten the pull required.

b. Installing Snatch Blocks. Select the side to be used as the return side and lash a snatch block to the vertical member on this same side of each tower. The same side of each tower is used to prevent crossing and fouling of the lines. Use ¼-inch diameter wire rope and lash the blocks about 3 feet off the ground or in a position that will keep the haul rope off the ground between towers. Blocks must be lashed to the terminal towers in this same position for a cableway or a tramway installation.

c. Rigging Return Side. Place the haul rope reel on a mandrel supported at the lower terminal. Tie the end of the haul rope to a timber about 3 inches in diameter and 6 feet long and drag it by manpower to the upper terminal. As the tower of the lower terminal is passed, place the haul rope in the snatch block. On a tramway installation, drag the haul rope through each intermediate tower, placing it in the snatch block as the tower is passed to lighten the load.

d. Crossing Streams. If a stream must be crossed, pull enough rope to the side of the stream to reach across it, coil it in the bottom of a boat, and pay the rope out over the stern as the boat crosses the stream.

e. Stringing Operating Side. At the upper terminal, for either a tramway or cableway, lash a second snatch block to the tower and place the haul rope through both snatch blocks. Pull the end of the haul rope by manpower back down to the lower terminal. On a tramway installation, pass through all intermediate towers on the way downhill, but do not place the haul rope in snatch blocks. If the pull is very heavy and a snatch block is needed to lighten the load, rig a snatch block temporarily but be sure and remove it as soon as the haul rope is completely erected. The operating side of the haul rope is being strung on the downhill trip and it must be

clear of obstructions to operate the carriage. When the lower terminal is reached, this end of the haul rope does not go through a snatch block at the tower (fig. 24) but goes directly to the power unit. It is now ready for connection to that part of the haul rope still on the reel.

f. Rigging at Drive Spool. Unreel some additional wire rope and lead this part of the haul rope from the lower terminal snatch block to the drive spool of the power unit. Take 3½ turns in this part of the rope about the drive spool, starting at the bottom and coming off the top. The connection to the carriage will be made in this operating side of the haul rope between the power unit drive spool and the upper terminal. Allow ample length to connect this to the end which has been pulled downhill and cut it off. Bend the end around a wire rope thimble and fasten the free end to the standing part with four wire rope clips. The slack must now be removed from the haul rope.

g. Removing Slack. Set the brake on the power unit so friction on the drive spool will hold the end of the haul rope with the thimble in it. Connect a hand winch to the end which was pulled downhill and take up on the winch until most of the slack has been removed. Tie a temporary snubbing line on this part of the rope to hold it until the ends are being connected, and take it off the hand winch.

h. Connecting Haul Rope. Place a thimble on the rope at a point which will just permit shackling the two thimbles together and bend the rope around the thimble. Fasten the wire rope to itself back of the thimble with four wire rope clips. Connect the two ends by placing a shackle through the thimbles. Cut off the excess rope behind the wire rope clips and untie the temporary snubbing line. Take up on the ratchet chain hoist in the anchorage sling for the power unit to pull the power unit away from the tower and haul any remaining slack out of the haul rope. Continue this until the haul rope is tight enough to operate without slipping on the drive spool. This tension can only be determined by operating the haul rope several times.

115. Erecting Track Cable

a. Track Cable Takeup. The takeup for the track cable at the lower terminal anchorage should be prepared before the track cable is placed. Since the track cable must be installed with a specified amount of tension due to erection sag, a tensionmeter (fig. 95) is included in the takeup gear. A tackle made up of two double-sheave blocks reeved with ¼-inch diameter wire rope is used. Attach one end of the wire rope to the becket of one block. Attach a wedge-type cable grip to this block to receive the track cable. Attach the other block to the track cable anchor sling. This anchor sling should be made of ½-inch diameter wire rope fastened with four wire rope

clips. Reeve the ¼-inch wire rope through the blocks with the blocks some distance apart. Hook the tensionmeter in a separate anchor sling and also in one end of the fully extended ratchet chain hoist. Attach a cable grip to the other end of the ratchet chain hoist but do not connect it to the cable. Mouse all hooks carefully to preve accidental slipping.

b. Placing Track Cable. Support the track cable reel on a ma at the lower terminal so that it is free to turn. Bend the end track cable around a wire rope thimble and fasten it to the sta part with three wire rope clips. Attach the thimble to the sh connecting the ends of the haul rope together. Operate the unit slowly to move the haul rope, pulling the end of the track to the upper terminal. In a tramway installation, station one at each intermediate tower before pulling the track cable into so that he can signal the power unit operator if trouble develo any tower. At the upper terminal, disconnect the thimble a end of the track cable from the shackle of the haul rope.

c. Upper Terminal. Throw a fiber rope over the crossmemb the upper terminal tower and tie it to the thimble on the track Using the fiber rope, drag the track cable end to its anchorage and remove the wire rope clips and thimble. If a standing tr stump is being used as an anchorage, take three turns in the cable about the tree and fasten the free end to the standing part four wire rope clips. If a deadman is used for anchorage, plac end of the track cable in a wedge-type cable grip and attach the grip to the anchor sling. When the wedge-type cable grip is install a safety rope. Attach a short piece of ½-inch diamete rope to the track cable above the cable grip and to the anchorage sling below the cable grip with four wire rope clips at each point. Leave as little slack in this safety rope as possible so that if the cable grip slips, the safety rope will take up the strain with a minimum of shock.

d. Intermediate Towers. On a tramway installation the track cable is placed in the track cable hangers at the intermediate towers before it is connected to the lower terminal anchorage. Start at the intermediate tower nearest the upper terminal and work toward the lower terminal, pulling up as much of the cable slack as possible as the cable is installed at each tower. To install the cable in the track cable hanger (fig. 88), unscrew the two clamp bolts and lift off the clamp. Grease the groove in the saddle and the inside of the clamp. Lay the track cable in the groove of the saddle and replace the clamp and clamp bolts.

e. Lower Terminal. Using a fiber rope, pull the track cable over the crossmember of the tower at the lower teminal and drag it to the lower terminal takeup gear. Haul as much slack as possible out of the track cable and place it in the wedge-type cable grip at the upper

block, holding the lead line of the extended anchor tackle while doing so. After attaching the track cable to the takeup gear, haul on the lead line of the tackle manually to take as much slack as possible out of the track cable with this 5 to 1 mechanical advantage. Hold the lead line under this tension and attach the cable grip on the ratchet chain hoist to the lead line. Operate the ratchet chain hoist to obtain the desired tension. Install a safety rope around the takeup tackle after the tension is set. Attach one end of a piece of ½-inch diameter wire rope to the track cable above the wedge-type cable grip with four wire rope clips. Take two turns in the other end of this safety rope around the anchorage tree, pulling as much slack out of the safety rope as possible, and fasten the free end to the standing part with four wire rope clips.

f. Track Cable Tension. The tensiometer indicates the tension applied to the lead line of the tackle by the ratchet chain hoist. It is graduated from 0 to 2,000 pounds at 100-pound intervals. Since the mechanical advantage of the tackle is 5 to 1, the indicated tension is one-fifth the tension in the track cable. All indicator readings must be multiplied by 5 to obtain actual tension. Desired tension in the track cable is not the same for a cableway installation that it is for a tramway installation.

(1) *Tramway.* The recommended track cable tension for this equipment, when installed as a tramway, is 4,000 pounds (tensiometer reading of 800 lb). A 1,000-foot span of ½-inch track cable at 4,000 pounds tension will be deflected approximately 40 feet at its center by a carrier containing a 350-pound load. Under the same load at the quarter-span points, the deflection would be three-fourths this amount. Allowing an additional 8 feet for carrier clearance, the profile can be checked for clearance. In cases where this tension will not provide clearance at a critical point, an additional intermediate tower should be erected. If this is impractical, track cable tension can be increased to as much as 7,000 pounds (tensiometer reading 1,400 lb) if the anchorages will withstand such a pull. If possible the tension should be maintained at 4,000 to 4,500 pounds.

(2) *Cableway.* In a 1,500-foot cableway installation the unloaded track cable tension should not be more than 1,600 to 1,700 pounds (tensiometer reading 320 to 340 lb) if maximum net loads of 2,000 pounds are to be carried. The unloaded sag at midspan under such tension is 81 feet, which will be increased to 116 feet when the fully loaded carrier is at midspan.

116. Carriage Assembly

a. General. Two carriages are supplied with the set. The cableway carriage cannot be used on a tramway because the framework will not pass a track cable hanger. The universal carriage can be used on a tramway or on a cableway. For cableway use, two cable guards are added to prevent it from jumping the track cable

b. Cableway Carriage. The cableway carriage (fi carriage with a tubular frame. Unscrew the four nut on the bottom of the carriage and remove the bolts rope shackles, and carrier sling shackles. Set the in place on the track with the track cable in the sheaves. Operate the power unit to move the con rope to a position at the carriage, or push the opposite the connection. Fasten a temporary r around the connection in the haul rope and remov ing the end thimbles. Slip one of the carriage through one thimble. Place this haul rope shackle and nut on the cableway carriage and tighten it. rope clips fastening the thimble in the other end o move the thimble about 3 feet to a new location to m of the carriage. Fasten the wire rope clips on the haul rop thimble in its new position. Slip the second carriage haul rop through this thimble and place it, the pipe spacer, bolt and nut o cableway carriage. Tighten all nuts on the carriage securely. U fasten and remove the temporary retaining cable holding the haul rope. The carrier sling shackles are left off until the carrier is assembled (para. 117).

c. Universal Carriage.

(1) *Assembly.* The universal carriage may be partly disassembled when received, with the haul rope grip (fig. 90), trolley sheave rocker arm, and cable guards removed. Assemble the trolley sheave rocker arm and haul rope grip on the carriage. To do this, grease the hole in the trolley sheave rocker arm and slip it over the shaft at the top of the carriage. Secure it in place with a flat washer and cotter pin. Unscrew the two slotted studs in the housing for the haul rope grip on the carriage and grease the housing carefully. Slide the haul rope grip into place in the housing and install the two slotted studs. Leave the cable guards off.

(2) *Tramway installation.* To install the universal carriage on a tramway, the cable guards are not used. If they are in place on the carriage, they must be removed prior to installation. Remove the two bolts through the trolley sheaves. Slide the

cable guards off the ends of the trolley sheave rocker arm and replace the two bolts. The upper ends of the cable guards are bent in, and they must be slipped off over the ends of the rocker arm. If they are pulled straight down they will be forced open and bent. Be careful not to permit dirt or foreign matter to get into the bearings of the trolley sheaves while removing the cable guards. Two men can now raise the carriage (fig. 90) and set the trolley sheaves on the track cable. The open side of the carriage must be placed so that it will pass the hanger arms on the track cable hangers (fig. 88). Fasten a temporary retaining cable across the connection between the ends of the haul rope. Move the carriage or the haul rope until the connection is opposite the carriage. Remove the shackle from the thimbles on the ends of the haul rope. Remove the wire rope clips and thimbles from both ends. Put each end through one eyebolt (fig. 90) on the carriage, pull it tight and fasten the free end to the standing part with wire rope clips. Remove the temporary retaining cable; the carriage is ready for operation. The haul rope grip provides an alternate method of connecting the haul rope to the carriage, leave the haul rope continuous. Open the haul rope grip and insert the haul rope in it. This system can also be used to connect two carriages to the haul rope for hauling pipe or other long loads.

(3) *Cableway installation.* If the cable guards are in place on the carriage they must be removed as in (2) above and replaced after the carriage is in place on the track cable. Two men can raise the carriage and set it in place with the trolley sheaves on the track cable. Support the carriage temporarily in this position to take the weight off the trolley sheaves. Remove the two bolts through the trolley sheaves and slip the cable guards into place over the ends of the rocker arm. The upper ends of the cable guards are bent in and they cannot be slipped straight up into position without bending them. Replace the bolts through the cable guards, trolley sheaves, and rocker arm. The cable guards will now prevent the carriage from jumping off the track cable. Remove the temporary support from under the carriage, making sure the track cable is seated in the grooves of the trolley sheaves. Cable guard removal and installation must be performed with care to prevent dirt and foreign matter from getting in the trolley sheave bearings. If dirt does get on them, wash all parts thoroughly and repack them with grease before installing them. Attach the ends of the haul rope to the carriage or grip the haul rope in the haul rope grip as in (2) above.

117. Carrier Installation

Assemble the carrier components into a short carrier (fig. 92) or long carrier (fig. 93), as may be desired. Four carrier slings are required for attachment of the carrier to the carriage. Make up the four slings, using ¼-inch diameter wire rope, fastening thimbles at both ends with wire rope clips. A sling length of 46 inches from inside to inside of the rounded portion of the thimbles will suspend the carrier so that its bottom is 6 feet below the track cable, using a universal carriage. Attach one end of each sling to a shackle plate on the carrier. Attach the other end of each sling to one of the corner shackles (fig. 90) of the universal carriage. On the cableway carriage insert each sling shackle (fig. 89) through the thimbles at the upper end of one pair of slings, and reassemble the sling shackles, pipe spacers, and bolts on the carriage. A safety hook is provided in the bottom of the universal carriage. The upper ends of the slings can be fastened to this safety hook for speed in changing carriers if possible rotating motion of the carrier, caused by single point suspension, will not interfere with operation nor cause it to strike the towers.

118. Toboggan Erection

To erect a toboggan hauling unit (fig. 86), the] rope, and toboggan are used, with two or three sna haul rope is dragged into place by manpower as outlin 99. Any intermediate snatch blocks used between th must be removed from the operating side of the h power unit is set in place and the haul rope ends are fastened toge to make it a continuous loop. The thimble in the hauling bridle (fig. 94) of the toboggan is fastened to the shackle at the connection of the haul rope ends. The power unit can now be operated to pull the haul rope back and forth, moving the toboggan up and down hill. Enough slack must be left in the haul rope so that the toboggan will not be pulled off the surface of the ground or snow at any point.

Section IV. OPERATION

119. Operating Crew

Eleven men are needed for normal operation, as a tramway or cableway. One man is stationed at the power unit as an operator. The remaining 10 men are split into 2 crews of 5 men each. One 5-man crew is stationed at each terminal for loading and unloading carriers.

120. Night Operation

Night and blackout operation reduce the speed with which men can load and unload the carrier but not the speed of operation of the equipment. However, the power unit operator cannot see the position of the carriage nor the progress of loading or unloading. To compensate

for this, telephone communication is necessary. Field telephones provided in the set are used. One telephone at the loading position, one at the unloading position, and one at the power unit are usually adequate.

121. Operating Power Unit

a. Procedure. The operator faces a footbrake, clutch lever, gear shift lever, emergency brake lever, a throttle, a governor control, a tachometer, starter, and choke control. Use the choke and starter ... engine and permit the engine to idle for several minutes ...erating the unit. The operator's platform should not ...ny time while the engine is running. A trainee operator ...illed in correct operation by an experienced operator. ...tion and maintenance instructions for the power unit ... a separate technical manual, TM 5–9157.

...*arriage.* Pull out the governor control and throttle ...o produce the desired rpm and twist them to the right ... in place. The engine rpm is the determining factor on ...age movement as there is only one gear ratio forward or ...r the drive spool. Set the emergency brake. Disengage ...nd place the gear shift lever in the desired position. Be ...l in selecting gear positions. The wrong selection may ...arriage into a tower, causing serious damage. The gear ... has three positions—forward, neutral, and reverse. It is ... necessary to engage the clutch momentarily to turn over ...ssion slightly in order to mesh the gears. Place one foot ...brake and release the emergency brake. Slowly engage ... while releasing the footbrake to take up the load smoothly. An abrupt start of the carriage places undue stress on all components.

c. Stopping Carriage. As the carriage approaches the unloading position, apply the footbrake slowly while simultaneously disengaging the clutch. Use the brake carefully to stop the carriage smoothly. A sudden stop may cause serious damage to equipment and personnel. Never apply the brakes suddenly when the carriage is in motion. Move the gear shift lever into the neutral position, release the clutch lever, and set the emergency brake. The footbrake may now be released. If the power unit is not going to be used again immediately, twist the governor control and throttle to the left to unlock them and reduce engine speed to idling.

122. Adjustments

When the installation is completed, trial runs should be made and the haul rope and track cable should be checked and adjusted New wire rope will stretch considerably in use. For the first few days the haul rope and track cable tension should be checked frequently and adjusted if necessary. For the trial runs on a tramway installation,

station a man at each intermediate tower and provide communication with the power unit operator to prevent damage. During the trial runs personnel at the towers should carefully observe the action of the return side of the haul rope in the snatch blocks. The power unit operator should observe the drive spool carefully for evidences of slippage. If slippage occurs the haul rope tension must be increased enough to cause it to rise above the track cable at any point as this would cause chafing and excessive wear. If the haul rope is chafing on a high point of ground along the route, a substantial log placed at that point will reduce the wear on the haul rope. After unloaded trial runs have been made, a loaded trial should be made. Place the maximum load in the carrier and carefully observe all critical points along the route for clearance as well as for the same conditions observed during the unloaded trial runs. In a tramway installation there should be a slight downward pressure of the track cable on the saddle of the track cable hanger at each intermediate tower. If the track cable shows enough tendency to lift to be retained in the saddle only by the clamp, the height of the track cable hanger at that tower must be increased to overcome it.

Section V. MAINTENANCE

123. Care in Handling

To attain maximum performance the equipment must be handled with care. Frequent lubrication will extend the life of the components. Smooth stopping and starting of loads will reduce the stress on the carriage, slings, and cable. The haul rope must not run faster than 310 feet per minute on a tramway installation but may be operated at speeds up to 580 feet per minute on cableway installations. The reduced speed on a tramway is to prevent the carriage from jumping off the track cable. When using the long carriers, do not overload them. They are not intended to carry heavier loads than the short carriers, but are available for use with bulky materials. The long carrier is used to accommodate battle casualties. When personnel are riding, they should seat themselves on the bottom of the carrier facing the direction of travel. Passengers must be warned not to let the carrier start swinging and not to permit arms or legs to protrude outside the carrier. Serious injury can be caused by failure to observe these cautions. The power unit operator must exercise great care to start and stop the carriage smoothly when hauling personnel. Bundled or packaged loads should be tied in place on the carrier.

124. Inspection

Inspect all components and fittings at frequent intervals. Examine guylines and anchorages, anchor slings, track cable, and haul rope.

Tighten loosened wire rope clips. Inspect wire rope carefully for worn or broken wires. Replace any wire rope which shows signs of cutting. Remove and straighten any bent or deformed parts on the carriage, carrier, or track cable hangers to prevent increased damage and unsatisfactory operation. Refer to TM 5-725 for detailed instructions on care of rigging.

125. Lubrication

All blocks and carriage sheaves must be lubricated at frequent intervals, the exact frequency depending on the amount of use. The components issued with the set are heavy duty units. If standard issue blocks are used at any point, a grease fitting should be installed and the block should be greased very frequently, as much as once per trip in some cases, to prevent cutting. It has been found that most failures in service of these units are caused by lack of adequate lubrication. Particular attention must be given to the lubrication of the power unit. Detailed lubrication instructions on the power unit are covered in the separate technical manual, TM 5-9157. Wire rope should be lubricated carefully at intervals to reduce deterioration. Refer to TM 5-725 for instructions on the lubrication of wire rope.

CHAPTER 8

LIGHT AERIAL TRAMWAY SET, M2

Section I. INTRODUCTION

126. Characteristics

The light aerial tramway set, M2 (figs. 2 and 97), is available as an issue set and can be erected as a tramway or as a cableway. The set was designed as a tramway and it is so treated in this chapter. However, the components can be used to erect a cableway. The set contains all equipment required to erect and operate a power-driven bicable tramway 3,000 feet in length with a maximum carrier load of 350 pounds. It has one-way capacity of 1 ton per hour or a two-way capacity of 2 tons per hour. Towers and other components are prefabricated and can be rapidly assembled. The M2 extension set contains components for extra towers, track cable, and haul rope to extend a tramway installation 1,000 feet. Since it does not rely on the use of native materials, the M2 set can be easily assembled under almost any conditions. This is the primary difference between this set and the M1 tramway (ch 7).

127. Equipment

Components included in the M2 set are listed in table X. The components included in the M2 extension set are listed in table XI.

Table X. Components Included in the 3,000-Foot Light Aerial Tramway Set, M2

Item	Quantity
Adjustment assembly, tramway track cable	2
Anchor assembly, end	2
Anchor assembly, haul rope	1
Angle, diagonal bracing	8
Block, tackle:	
Plain becket	2
Special becket	2

Table X. Components Included in the 3,000-Foot Light Aerial Tramway Set, M2—Continued

Item				Quantity
Bolt, machine:				
	Diameter, inches	*Length inches*	*Thread length, inches*	
	3/8	1 1/4	3/4	18
	3/8	1 1/2	7/8	16
	3/	2	7/8	108
		1 1/4	1	56
		4 1/2	1 1/4	65
		1 1/4	7/8	98
		4	1 1/2	24
				350
				1
e				36
erminal frame				2
eave				2
ler				18
hanger				18
ertical, for truss section T–1				4
ertical, for truss section T–1A				4
od, tramway tower				72
ramway tower				36
ter				220
ter				50
gle				36
Crossmember, pipe				36
Crosstie				1
Drive unit, aerial tramway-cableway				1
End, steel, weight box				2
Frame, center splice, weight box mast				1
Grip, cable, jaw:				
Parallel				2
Wedge and roller				2
Hanger assembly, carrier				4
Hoist, chain				2
Nut, plain hexagon				10
Pin, cone head				121
Pin, connecting, truss				6
Pin, cotter				559
Pin, coupling				56
Pin, hinge, weight box:				
	Diameter, inches	*Length, inches*		
	1/2	15 1/4		4
	1/2	24 1/4		8
	1/2	48 1/4		4
Pin, tee iron				50
Platform, screen, carrier				4
Platform, wood				8
Platform, wood, carrier				4
Platform unit, bottom chord				16

Table X. Components Included in the 3,000-Foot Light Aerial Tramway Set, M2—Continued

Item	Quantity
Platform unit, top chord	2
Rod, adjusting tower	72
Rod guide, tower	36
Saddle and clamp, cable track	18
Screw, cap, hexagon head	10
Section, lower, weight box mast	2
Section, upper, weight box mast	2
Separator, carrier drawbar	16
Separator, terminal frame:	
½-inch diameter, 3 inches long	39
½-inch diameter, 3⅝ inches long	26
Separator, tower	18
Setscrew:	
⅜-inch diameter	15
¾-inch diameter	50
Sheave, bolt	6
Shield, expansion	75
Side, weight box	2
Socket, double, pipe	36
Support, platform, adjustable	4
Support, platform, fixed	4
Support, sheave, weight box mast	1
Swivel, link and jaw	6
Tensiometer, dial indicating	2
Thimble, rope:	
¼-inch diameter	100
½-inch diameter	12
Truss, diagonal bracing, horizontal:	
With female hinge	4
With male hinge	4
Truss, lateral	6
Truss section:	
Terminal frame	4
With hinge	4
With hinge and mast socket	4
With mast socket	4
Turnbuckle	76
U-bolt and washer, bridge	36
Vertical member	120
Washer, flat:	
⅝-inch bolt size, 1¾-inch diameter	1
1-inch bolt size, 2½-inch diameter	2
Washer, lock:	
⅜-inch screw size	2
⅝-inch screw size	1
Wire rope, steel	8
Wire rope assemble, single leg	12

Table XI. Components included in the M2 Extension Set

Item	Quantity
	24
	120
e	8
er	6
anger	6
d, tramway tower	24
amway tower	12
	125
	12
	8
	15
r	24
	12
ble track	6
	6
	6
	16
	12
	20
, bridge	12
	36
	3,000 ft.
y	4

Description

a. General Design. The set includes prefabricated sections to construct two terminals and a number of intermediate towers of varying heights. A power unit, two track cables, components for four carriers, and haul rope are included. After construction the terminals are ballasted and serve as anchorages for the track cables. Haul rope tension is maintained by a suspended weight box on the operating terminal. The haul rope moves two carriers, one on each track cable. The carriers are arranged so that one is at the upper terminal when the other is at the lower terminal. Normally the power unit is placed at the lower terminal, which is then used as the operating terminal.

b. Upper Terminal. The upper terminal (fig. 98) serves as an anchor for the track cables and includes an anchor assembly with two sheaves for the haul rope. Two main truss assemblies are connected together at their bottoms by horizontal diagonal bracing trusses. Three lateral trusses brace the other members in a box form. Vertical anchor channels are placed at the front of the terminal and held in place by a horizontal brace across their tops and diagonal bracing angles back to the main truss assemblies. Bottom chord

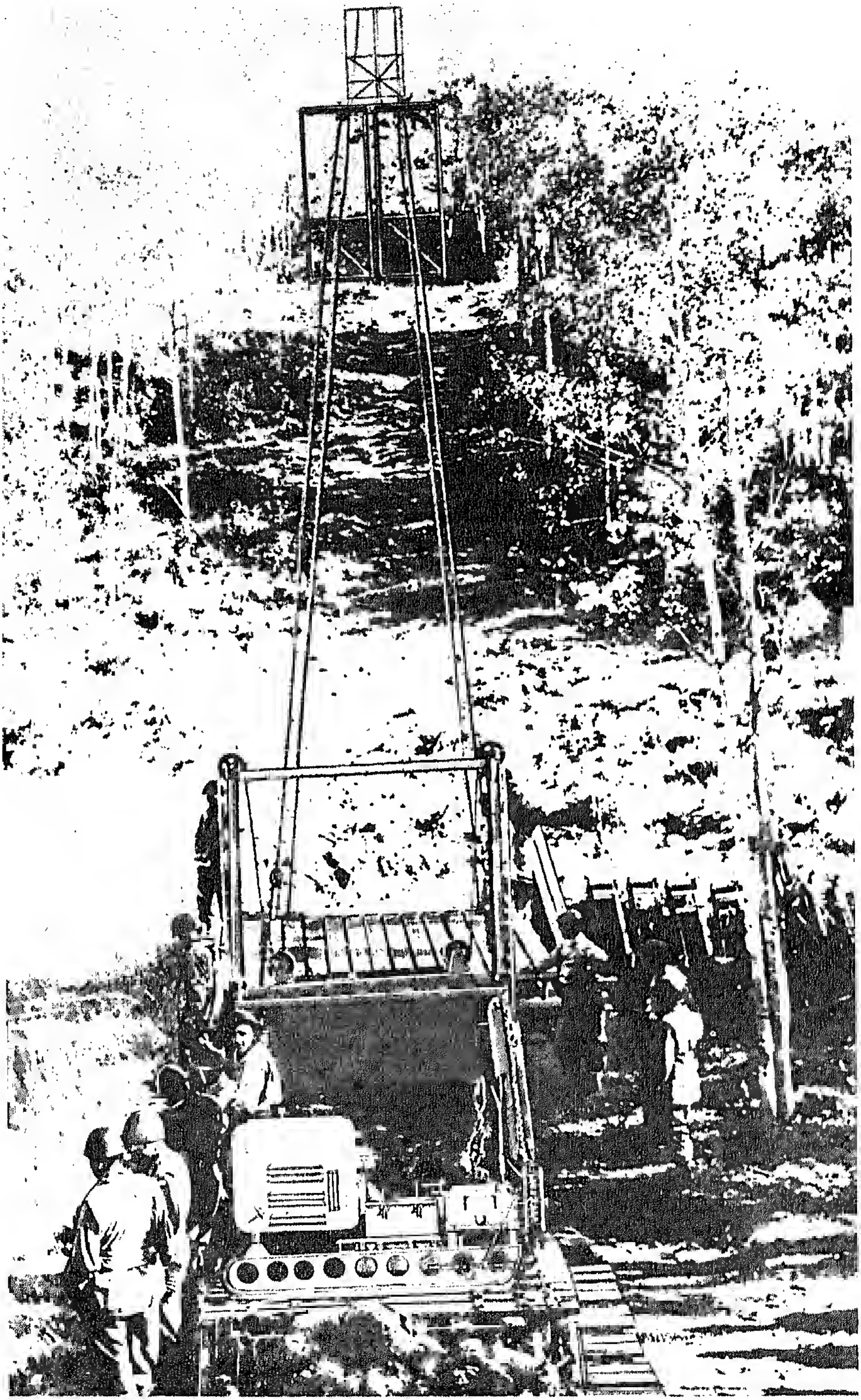


Figure 97. Features of light aerial tramway M2.

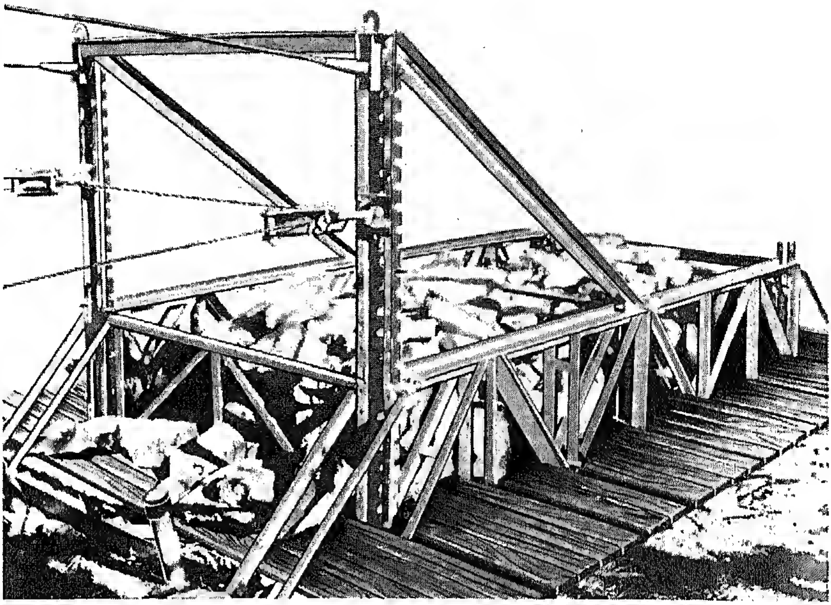


Figure 98. Upper terminal.

planking is laid across the bottom of the main truss assemblies and rocks are placed on the planking for ballast.

c. Lower Terminal. The basic frame of the lower terminal is identical with the upper terminal (*b* above) except that it has no anchor assembly for the haul ropes. Top chord planking (fig. 99) is added to support the power unit. A weight box and weight box mast assembly are added to provide tension on the haul rope. Takeup tackle is added to supply the tension on the two track cables.

d. Towers. Each single tower is made up of a main bent and as many auxiliary bents as are needed to attain the desired height. The main bent is made up of pipe vertical members and angle crossmembers. Auxiliary bents are made up of pipe vertical members and pipe crossmembers with pipe diagonal braces. Two such single towers (fig. 100) are fastened together with U-bolts and separators to make one intermediate tower. The angle crossmember at the top of each single tower supports a saddle hanger bracket assembly. An idler sheave bracket assembly is mounted on the angle crossmember at the bottom of each main bent to guide the haul rope through the tower.

e. Track Cables. There are two track cables. Each track cable is made up of 500-foot lengths of ½-inch diameter 6 x 7 wire rope. The upper end of each track cable is anchored at the upper terminal. The track cables are supported at the intermediate towers by track cable hangers. The lower end of each track cable is fastened to takeup gear

at the lower terminal. The takeup gear includes two blocks, a lever operated chain hoist, and a tensiometer for setting the correct track cable tension.

f. Haul Rope. The haul rope is made up of 1,500-foot lengths of ¼-inch diameter 6 x 7 wire rope. The haul rope leads from one carrier assembly to the upper terminal and back down to a second carrier assembly. Another part of the haul rope leads from this second carrier assembly down to the lower terminal, around the drive spool of the power unit, through the sheaves of the weight box mast assembly, and up to the first carrier assembly. The weight box rides on the haul rope to maintain tension.

g. Carrier Assembly. Each carrier assembly (fig. 101) is made up of a carrier platform, two carrier platform supports, and a carrier hanger assembly. The platform support on the uphill side has adjustable sleeves to change its length so that the platform can be made horizontal regardless of the inclination of the track cable.

h. Power Unit. The power unit operates the haul rope to move the carrier assemblies back and forth. A power unit has been developed for use with the M1 and M2 light aerial tramways and the medium cableway. It is an inclosed skid-mounted gasoline-engine-driven unit (fig. 102) delivering 20 hp at the drive spool at a crankshaft speed of 2,250 rpm (Continental Model SF–162) complete with an industrial

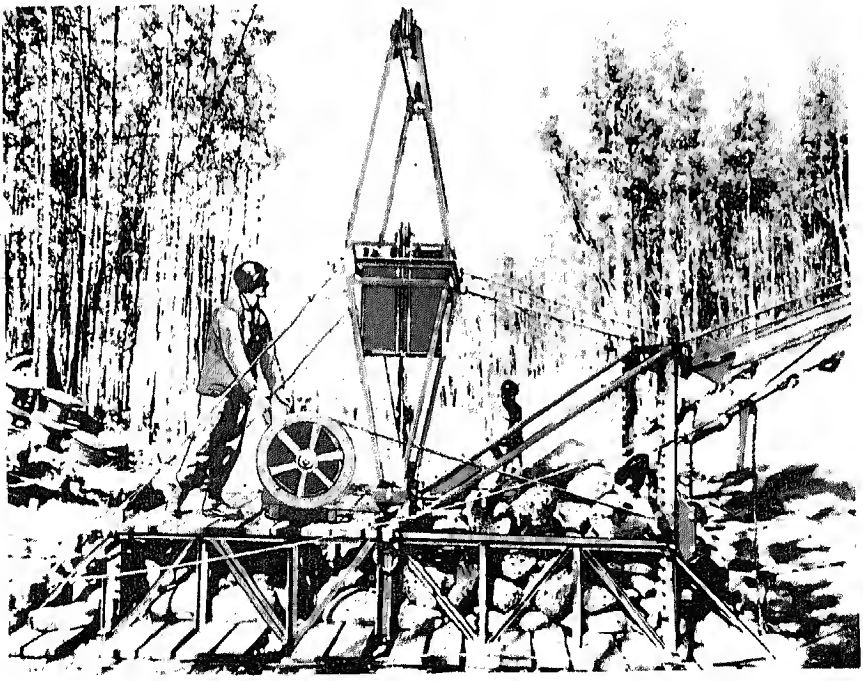


Figure 99. Lower terminal.

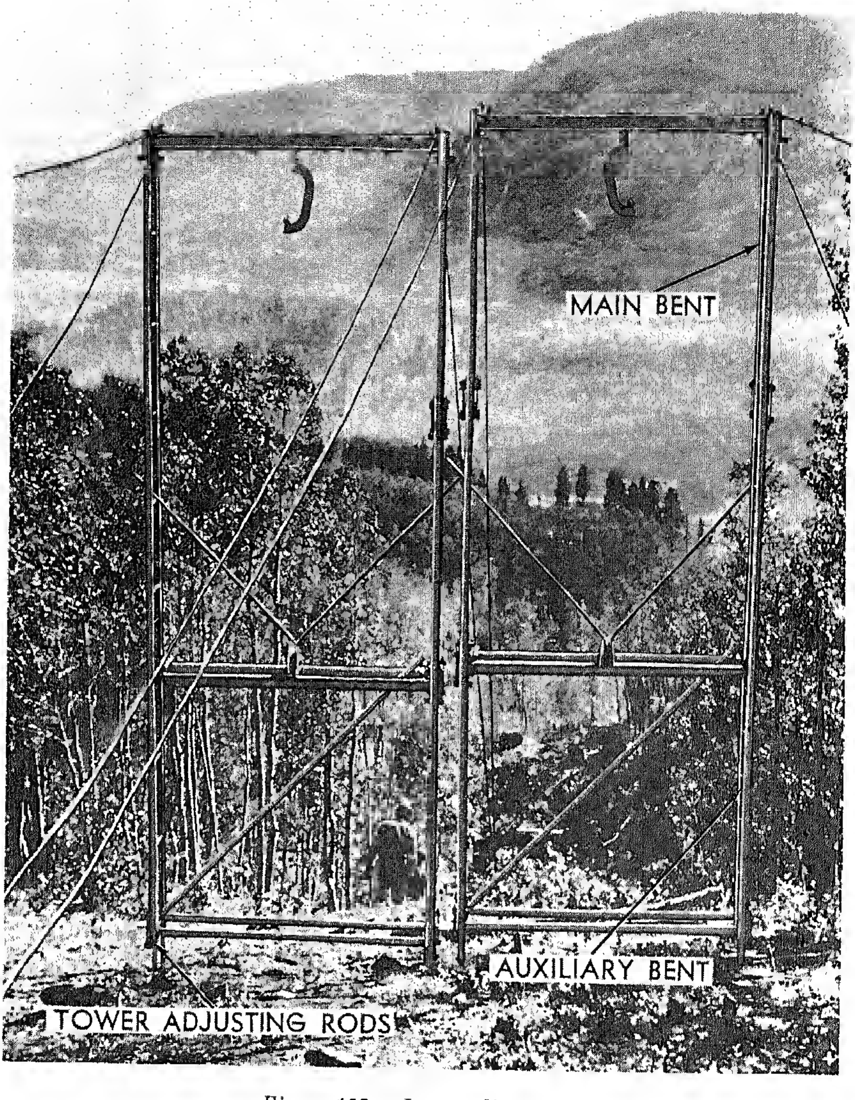


Figure 100. Intermediate tower.

clutch, muffler, radiator, and head. A double universal with slip propeller shaft drives a heavy duty industrial type transmission with a forward and reverse drive ratio of 40 to 1. A drive spool for the haul rope is located on the output shaft at the rear end of the unit. The power unit is operated in forward or reverse drive to move the carrier assemblies in the desired direction. Detailed operation and maintenance instructions for this power unit are covered in a separate technical manual, TM 5-9157.

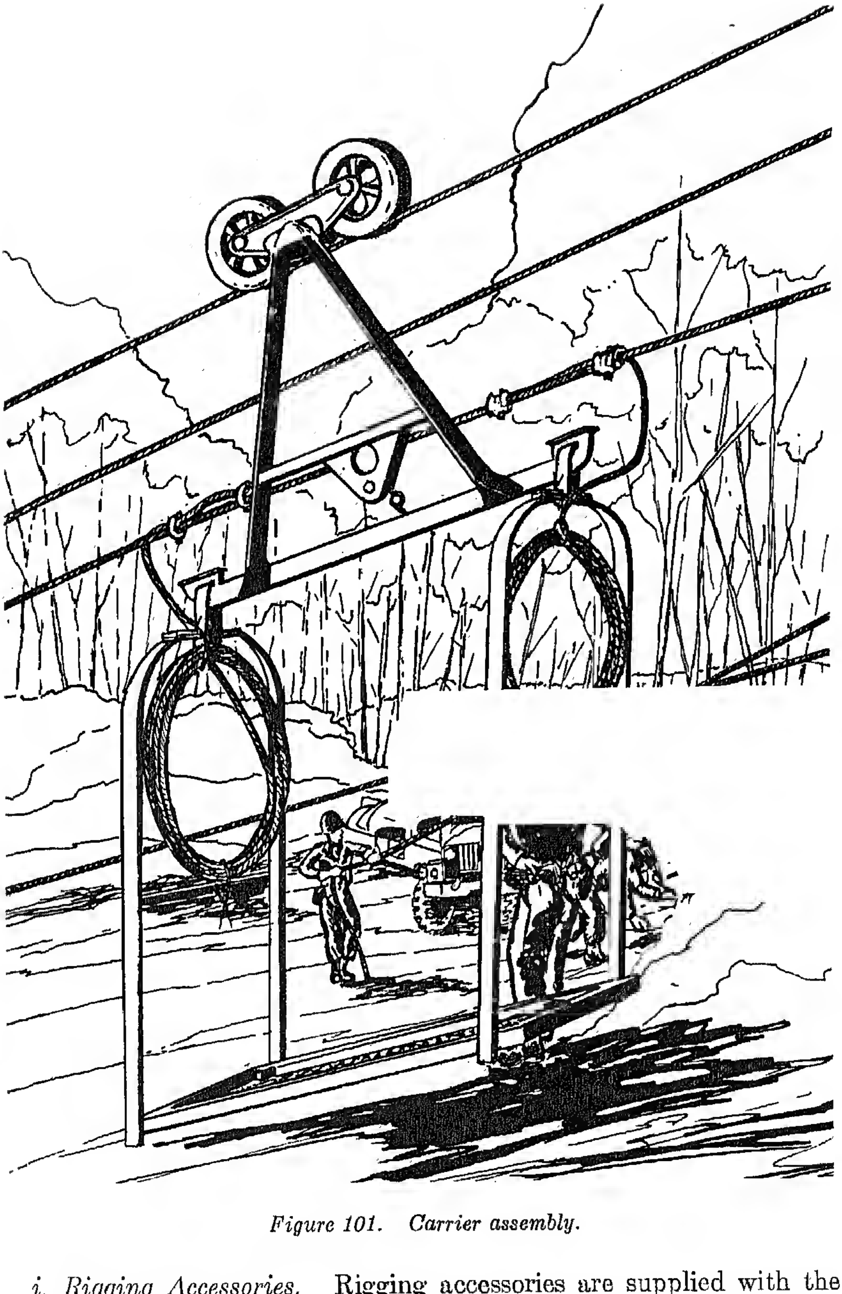


Figure 101. Carrier assembly.

i. Rigging Accessories. Rigging accessories are supplied with the set. Two tensiometers are included and lever operated chain hoists for use in the track cable takeup gear at the lower terminal.

129. Transportation

Components of the light aerial tramway M2 can be transported in four 2½-ton 6 x 6 cargo trucks or twelve ¾-ton 4 x 4 cargo trucks.

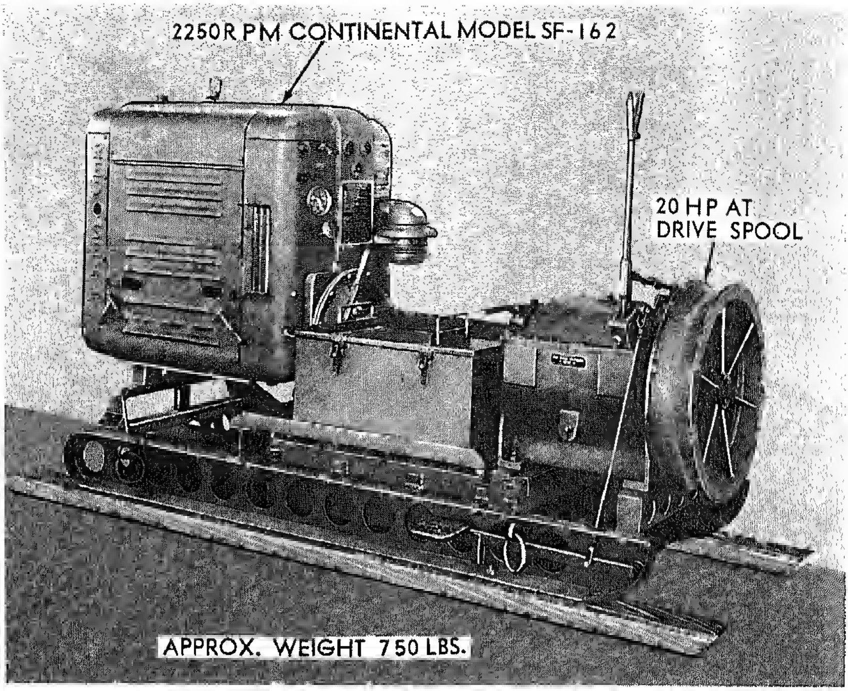


Figure 102. Power unit.

Section II. ERECTION PROCEDURE

130. Considerations

After the site is selected, it should be surveyed and a profile drawn to determine tower heights and locations, or if a cableway erection would be preferable. The working party and erection tools must be so placed at the site that the various parts of the installation reach completion in a sequential manner. This section will deal only with these phases of erection. Actual construction of towers and erection of components are covered in paragraphs 138 through 146.

131. Site Requirements

Make a visual survey of the general area before selecting the actual site. The site must be accessible so the tramway components can be transported to the site prior to erection and materials and supplies can be brought to the site for transportation over the tramway. The towers of the tramway should lie in a straight line, and the average chord slope must not be over 35°. Towers must not be located on concave slopes since no provision is included for holding down the track cable and haul ropes at intermediate towers. Sharp crests should be avoided, as the maximum deflection angle of the

track cable (fig. 96) over a saddle at an intermediate tower is 10°. Maximum length between terminals must not exceed 3,000 feet, measured along the track cable, for an M2 set, or 4,000 feet if an M2 set and an M2 extension set are used. If a greater length must be covered, two tramways must be used in tandem and the upper terminal of one must be adjacent and parallel to the lower terminal of the other for ease in transferring loads from one to the other. If possible, the area should be relatively free of trees and brush. A site where only a small amount of clearing is required will be less noticeable from the air and will require less work in the preparation of the site. Vertical rock faces should be avoided because of the difficulty of transporting parts and men during construction.

132. Survey

After the site has been selected it must be surveyed. Two or more transits are desirable. Locate one terminal and set up one transit there. Locate the other terminal and establish the centerline of the installation on the ground. Use the first transit to keep the other transit in line and make a stadia survey of the terrain between terminals. From this survey draw up a profile to a convenient scale of the centerline. From this profile, tower locations and heights for a tramway installation can be determined. Intermediate towers in a tramway are intended to provide sufficient ground clearance for loaded carriers and they are therefore placed at high points on the profile that would otherwise interfere with carrier movements. If transits are not available for a survey, this same information must be obtained in a personal reconnaissance by the officer in charge, who can plan tower locations on the spot.

133. Determination of Tower Height

In order to determine tower height, obtain the proposed length of span from the profile (para. 132). Using 3 percent of the span as the track cable deflection at the midpoint of the span and an additional 6 feet to obtain carrier clearance, the interference at midspan can be obtained. Minimum tower height must be this same amount. If the minimum tower height is unreasonably high, an intermediate tower must be placed at the high point causing the problem. Similarly, clearance at the quarter-points of the span can be computed, using a track deflection at these points three-fourths of the track deflection at the center of the span, or the approximate deflection can be obtained from the chart in figure 103.

134. Working Party

The working party must be subdivided into groups and each group assigned to one phase of the operation so that all phases can progress concurrently. For tramway erection, five or more groups are needed.

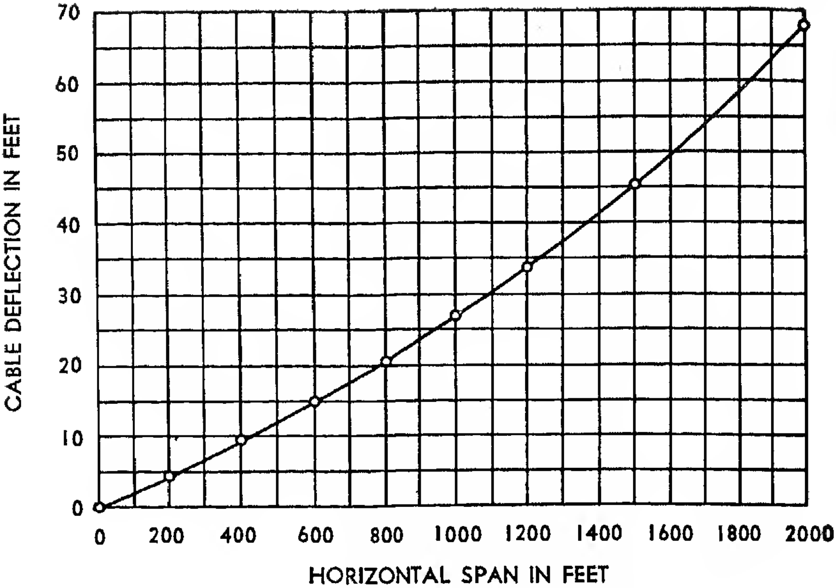


Figure 103. Track cable deflection for tramway planning.

, one group to each terminal, one group to clearing undergrowth along the line that might interfere with operations, and a fourth group to moving components to the upper terminal. One additional group should be set up and assigned for each intermediate tower.

135. Clearing

Clearing of timber should be kept to a minimum to reduce the possibility of aerial observation. However, trees and undergrowth that will interfere with the operation must be removed. Usually on a cableway there are only a few points that must be cleared. On a tramway it may be necessary to clear a right-of-way for a considerable distance. The size of the working party required for clearing will vary considerably and can only be determined from the requirements at the site.

136. Moving Components

Components may be moved to the upper terminal and intermediate towers on vehicles if they are sufficiently accessible. Many of the components can be carried by men. In very difficult terrain these methods are not always feasible and skid hoists are included in the set for such occasions. The skid hoist (fig. 104) consists of an engine and winch with 1,200 feet of wire rope mounted on a curved steel toboggan. The skid hoist can pull itself up the slope. Run out the winch line, drag the end of it up the slope, and pass it through a snatch block fastened to a tree. Bring the end back down the slope and hook it in

the bridle at the front of the toboggan. When the engine is operated to take up on the winch line, the skid hoist will be pul
the skid hoist in position, pass the winch line throug
and hook the end of it to the bridle on the skid hoist.
block downhill while paying out the winch line and
block to one of the toboggans from the set. The s
be used to pull components up the hill on the tobogg
of the skid hoist involves rigging a skyline. To do
end of a section of track cable near the skid hoist and
a terminal point downhill. Place a snatch block o
as a traveling block. Fasten a double block to th
and use a single block as a fall block. Reeve the w
the double block, down to the fall block, back th
block, and fasten the end to the becket of the fall blo
winch line, permitting the traveling block to run
downhill terminal. Hook a load to the fall block a
winch line. The fall block will be lifted to the dou
whole combination will be pulled up to skyline to th

137. Erection Tools

Erection tools should be distributed to the various
in a manner that will expedite the construction. To
set are listed in table XII.

Figure 104. Skid hoist pulling itself up a slope.

Table XII. Tools Supplied With Set For Light Aerial Tramway M2

Item	Quantity
Ax, double bit	12
Battery, dry	36
Bit, auger	4
Blade, hand hacksaw	144
Block, tackle	12
Blowtorch, gasoline	1
Brace, bit, ratchet	3
Cable, telephone	2
Carrier, tool	24
Chisel, cold, hand	6
Coal, bituminous	2
Crowbar	12
Driftpin	6
Drill, masonry, hand:	
¾-inch	25
1-inch	25
File, hand	12
Fire pot, liquid fuel	1
Forge, coal burning	1
Frame, hand hacksaw	3
Goggles, industrial	2
Grease gun, hand	1
Grinding machine, bench, hand operated	1
Grip, cable, jaw:	
Parallel	2
Wedge and roller	2
Hammer, hand:	
Carpenter's	12
Machinist's, ball-peen	6
Striking, drilling	12
Hoist, chain	1
Hydrochloric acid, technical	2
Insulation tape, electrical:	
Cotton, adhesive	12
Rubber, adhesive	6
Ladle, melting, hand	1
Level and plumb	6
Mallet, wood	18
Marlinespike:	
10-inch wire rope	6
14-inch wire rope	6
Mattock	12
Nippers, end cutting	6
Nut, plain, hexagon	72
Oiler, hand	2
Pliers	12
Pot, melting	1
Rope, manila	1,200 ft
Safety can, fuel	2
Saw, crosscut, two-man	4
Saw, hand, crosscut	6

Item	Quantity
Screw, cap, hexagon head	72
Screwdriver, flat tip	12
Shovel, hand, D-handle:	
Round point	12
Square point	12
Stone, sharpening	4
Telephone set, field type	6
Toboggan, cargo	4
Tool box, portable	2
Turntable	2
Washer, flat	3
Winch, drum, hand operated	2
Winch, drum, power operated	2
Wire, steel, carbon:	
5-lb coil, .0475-inch diameter	2
12-lb coil, .0800-inch diameter	1
12-lb coil, .1055-inch diameter	3
Wire rope, steel	2
Wrench, open end, adjustable:	
0- to 1 5/16-inch jaw opening, 8 inches long	12
0- to 1.322-inches jaw opening, 12 inches long	24
Wrench, pipe	12
Wrench, spanner	12
Zinc slab	25 lb

Section III. CONSTRUCTION

138. Procedure

The towers and basic terminals are constructed first. At the lower terminal a weight box mast assembly and power unit must be added to the basic terminal. The track cable is then strung and rigged. The carriers are assembled and placed on the track cable and the haul rope is then strung and rigged to the carriers. The haul rope can be rigged and used to pull the track cables into place as an alternate method.

139. Towers

a. Description. Each intermediate tower is really a double tower (fig. 105) made up of two single towers fastened together with separators. Each single tower consists of a main bent (fig. 100), with any number of auxiliary bents, sitting on tower adjusting rods (fig. 106). Nominal height of each main bent is 12 feet, to provide carrier clearance; each auxiliary bent, 6 feet, so that tower heights may be 12, 18, 24, 30, 36, or 42 feet. Towers higher than 42 feet should not be erected. Each prefabricated pipe vertical member is 5 feet 7 inches long. One pipe vertical member is used on each side of an auxiliary

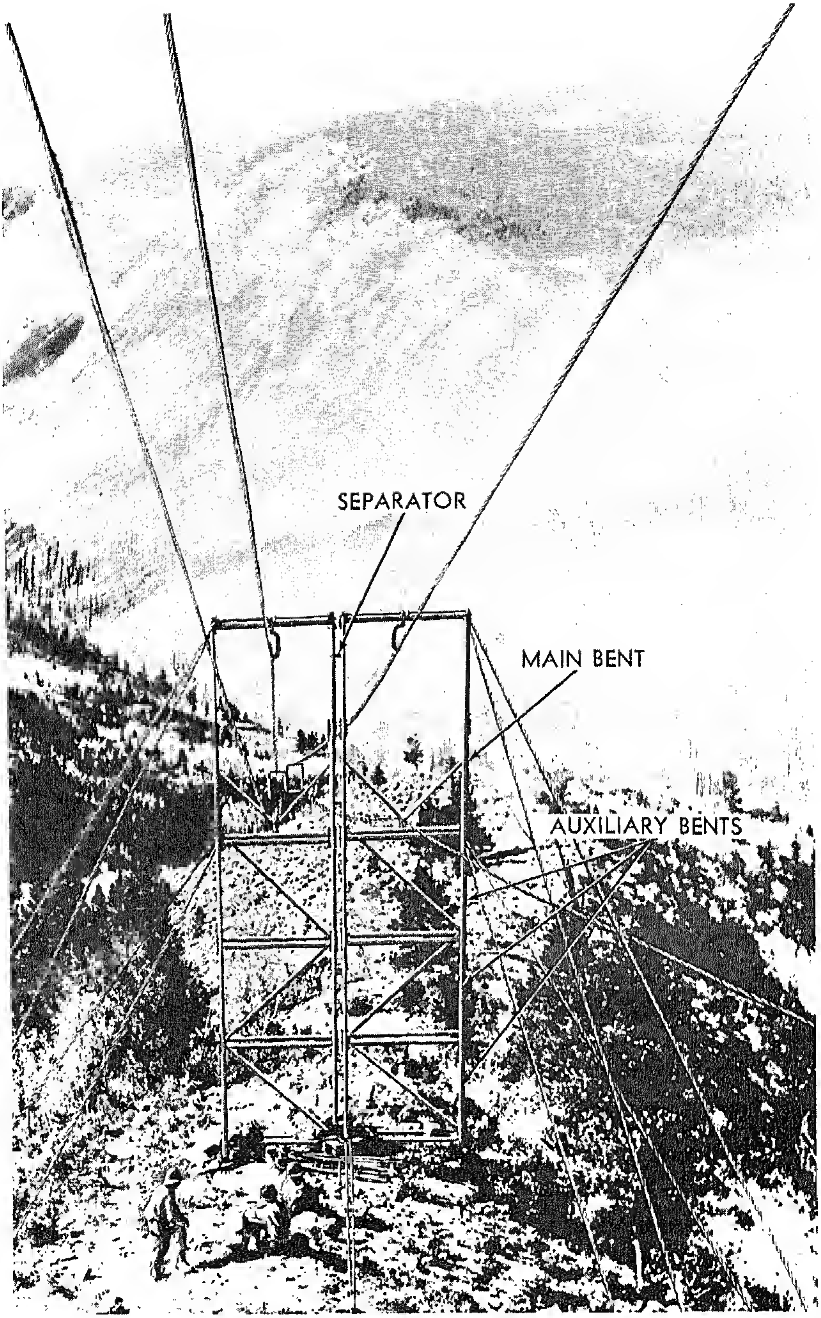


Figure 105. Double tower installation.

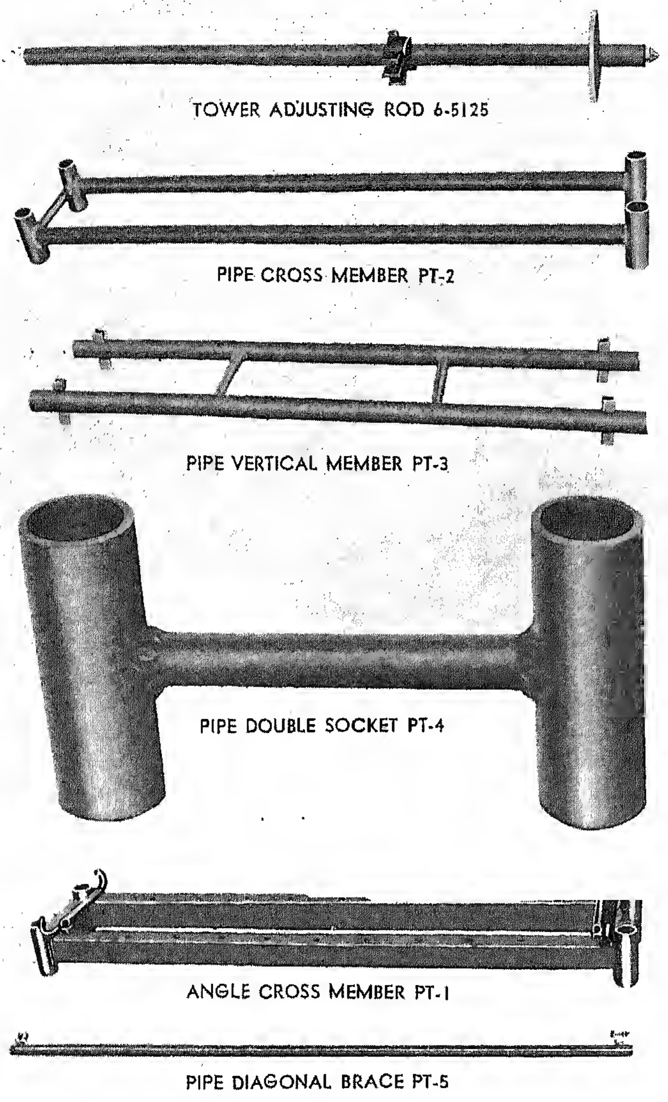


Figure 106. Tower components.

bent, and two are used on each side of a main bent. The bottom and top of each main bent is an angle crossmember with holes drilled in it for mounting other components. The bottom of each auxiliary bent is a pipe crossmember. A pipe diagonal brace is fastened in each auxiliary bent to strengthen it.

b. Erection. The tower (fig. 107) is assembled and erected at the same time. The tower adjusting rods are set in the ground first and

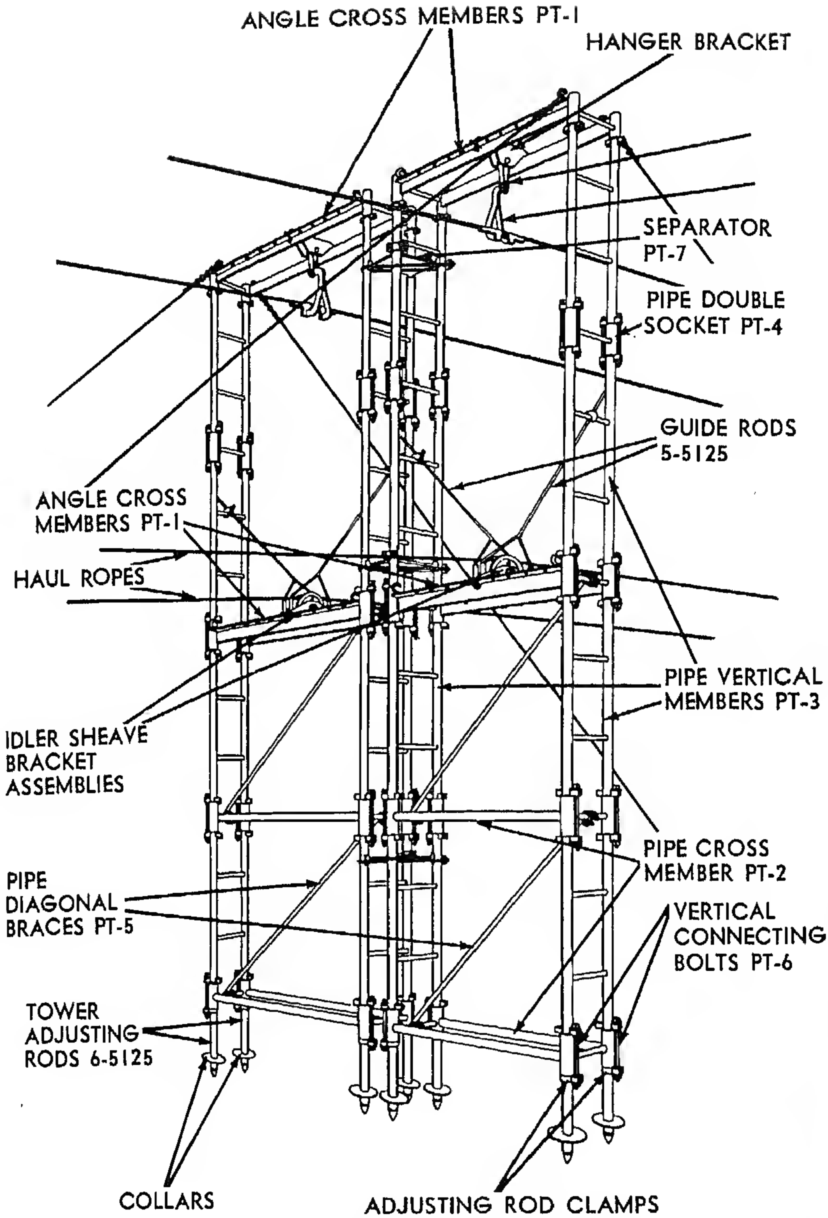


Figure 107. Detail of assembled tower.

their alinement is of great importance since the final tower alinement depends on it. Clear the area for the base of the tower and place two pipe crossmembers on the ground as templates. Line these up end-to-end at right angles to the centerline of the tramway and one on each side of the centerline. Place a separator between them (fig. 108) to

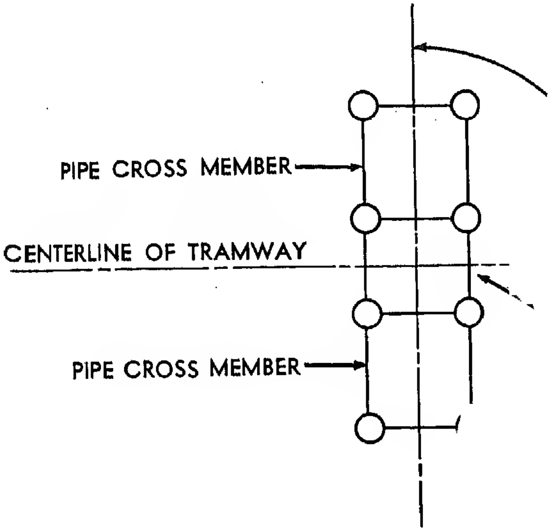


Figure 108. Layout o

gage their distance apart. Mark the grounc the vertical pipes of these templates and rei tower adjusting rod (fig. 106) is to be placed at ... is driven into the ground until its collar is resting or rods must be absolutely vertical; use a level to tower adjusting rods are to be placed in rock, holes a... must be drilled for them. The holes should be just ... (1$\frac{7}{16}$-in. diameter) to fit the adjusting rods tightly and ... vertical. Chip a reasonably level area about 6 inches in diameter around the hole for the collar of the adjusting rod. Place the adjusting rods in the holes. Set the two pipe crossmembers back in position over the adjusting rods. Place a level on each of the pipe crossmembers and move the individual adjusting rod clamps (fig. 106) up or down as necessary to make each pipe crossmember level. The two pipe crossmembers do not need to be at the same elevation, as double towers may be installed in sloping ground (fig. 109). All four corners of each pipe crossmember must be resting on an adjusting rod clamp. Tighten the bolts in all adjusting rod clamps securely, as they will support the tower. If the first bent is to be an auxiliary bents, remove the pipe crossmembers and replace them with angle crossmembers. Place a pipe vertical member in each side of each pipe or angle crossmember. Connect the lugs on the pipe vertical members to the lugs on the adjusting rod clamps with vertical connecting bolts (Mark PT–6) and tighten the bolts. If this is an auxiliary bent, place a pipe or angle crossmember over the top, depending on whether the next bent is the main bent, and bolt a pipe diagonal brace into place to

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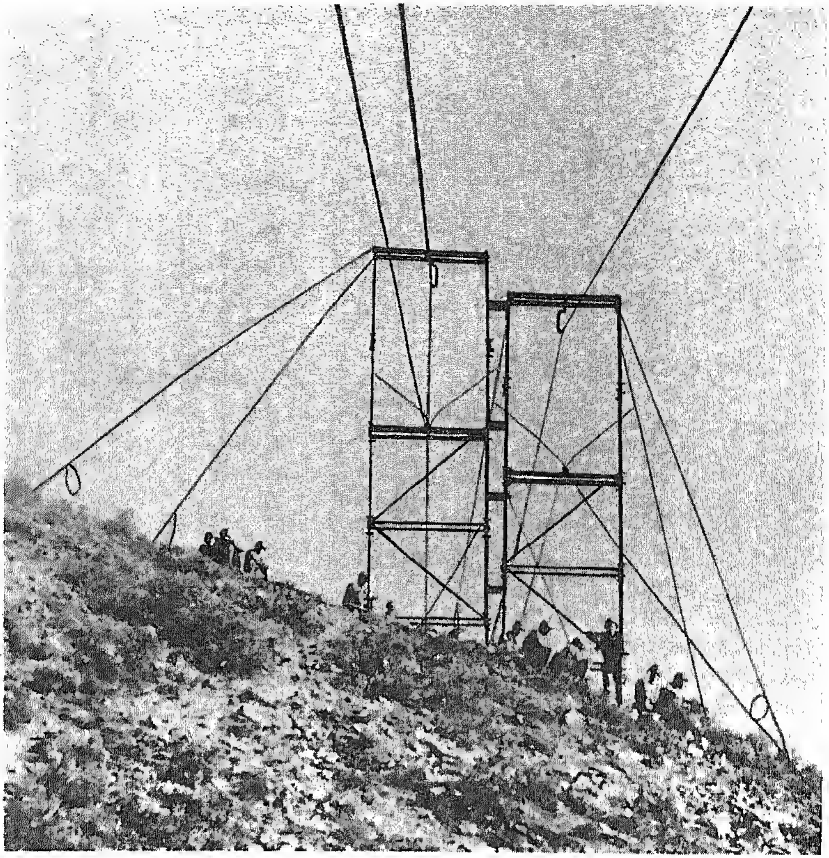


Figure 109. Double towers installed on a slope.

strengthen the bent. If this is the main bent, place a pipe double socket (fig. 106) on each pipe vertical member, and place a second pipe vertical member in the top of each pipe double socket. Connect the pipe vertical members with vertical connecting bolts. Place an angle crossmember across the top of these upper pipe vertical members. These steps must be combined as necessary for the individual tower.

c. Tower Separators. Tower separators (fig. 110) are used to space and connect the two single towers to reduce the number of guylines required. When each tower consists of a main bent only, place one separator near the top. When the towers include auxiliary bents, place two separators for the main bent and one separator for each two auxiliary bents. To install a separator, place it in position between the four vertical pipes and install one U-bolt above it and one below it, connecting the pipes diagonally. Avoid installing separators near the center of pipe vertical members, as the U-bolts tend to bend the pipes sideways. If the number of separators available is inadequate, expedient separators (fig. 110) can be made of

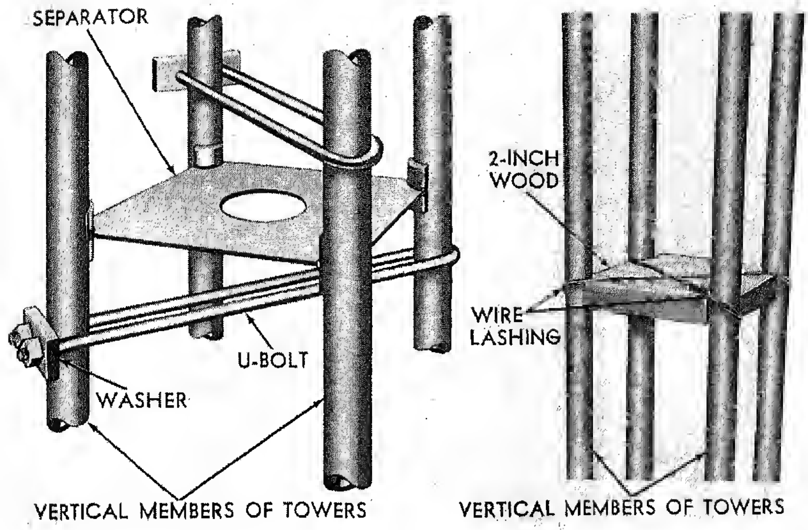


Figure 110. Tower separators.

lumber 2 inches thick, cut to size, and notched at the corners. Wire lashing can be used for expedient separators instead of U-bolts.

d. Guylines. Each angle crossmember (fig. 106) is provided with four hooks for installing guylines. In a single tower installation, four guylines are required. In a double tower installation with separators (fig. 105), two guylines are installed at the outer hooks of each single tower. Because these towers are 30 feet high, two additional guylines are required on each tower and are connected to the hooks on the angle crossmembers at the bottom of each main bent. This second set of guylines is to reduce the buckling stress on the towers and is not for 24 foot, or lower, towers. Anchor the guylines to standing trees, pickets, or rock anchors (par. 38).

e. Tower Fittings. The angle crossmembers (fig. 106) used at the top and bottom of each main bent contain a series of holes for installing the idler sheave bracket assembly (fig. 111) and the saddle hanger bracket assembly (fig. 112). Each of these fittings is placed in position with their pins in holes in the angle crossmember at the bottom of the main bent. Place the lower ends of two guide rods in two of the four guide rod sleeves on the idler sheave bracket assembly and clamp the tops of the guide rods to crosspieces of pipe vertical members. It is important that the guide rods be installed in such a manner that they guide the haul rope to the center of the idler sheave. There must be no gap that would allow the haul rope to slip between the guide rods and sheave flanges. If necessary, bend the guide rods to avoid this. The saddle hanger bracket assembly must be placed

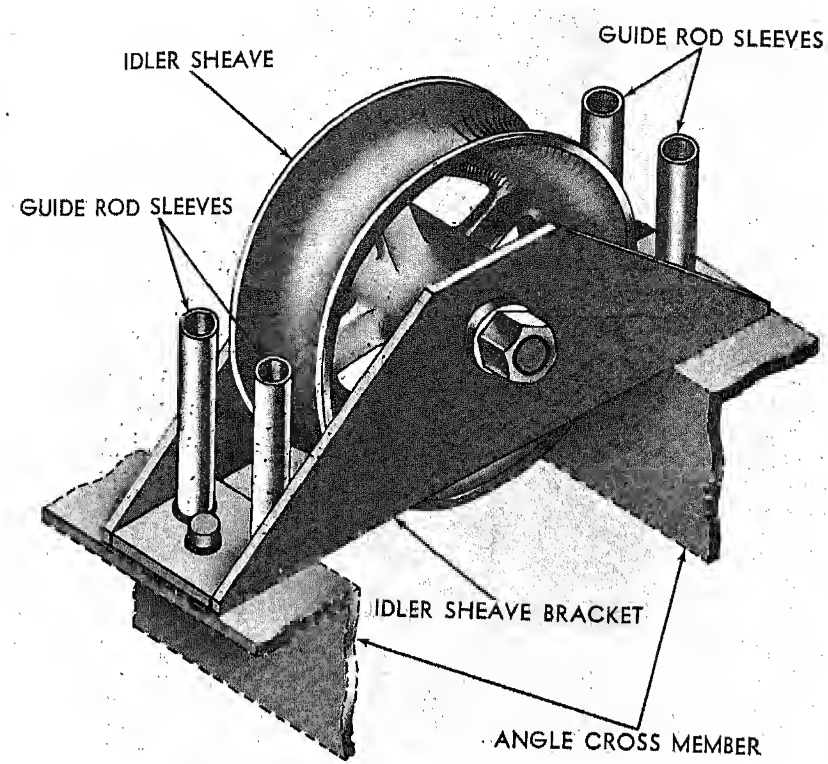


Figure 111. Idler sheave bracket assembly.

so that the open side is the side away from the centerline of the tramway.

140. Terminals

a. Truss Assemblies. The basic units of the upper and lower terminals (fig. 113) are identical. Two main truss assemblies are used in each terminal. Each main truss assembly is made up of two truss assemblies pinned together. Each truss assembly is composed of two truss sections. The truss assemblies normally are transported as units, but are disassembled into truss sections for small vehicle transport. If they have been disassembled, there will be four of each truss section, T–1, T–1A, T–2, and T–2A. A T–1 and T–1A truss section are assembled together parallel to each other with pipe spacers and machine bolts. A T–2 and T–2A truss section are similarly assembled together parallel. Continue in this manner until there are 8 truss assemblies, 4 "ones" and 4 twos". Two of each are used in a terminal. A "one" and a "two" truss assembly are placed together end-to-end and connected with a truss pin, making an 18-foot main truss assembly.

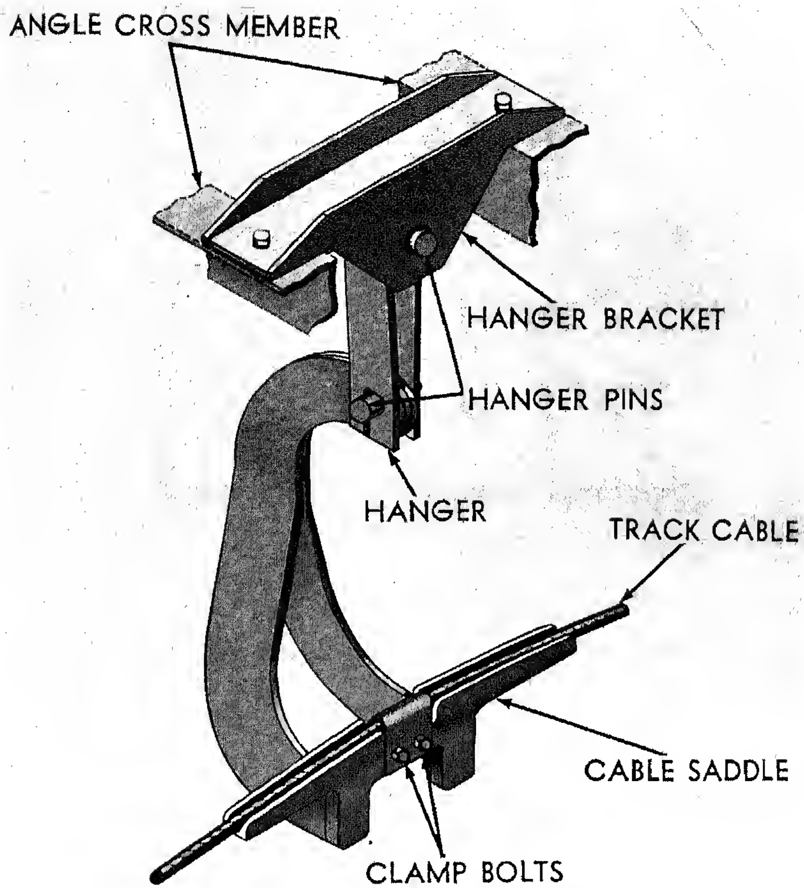


Figure 112. Saddle hanger bracket assembly.

b. Terminal Erection. Smooth and level the ground for a strip 20 feet long lying on the centerline of the tramway and 6 feet on each side of the centerline. The 12-foot width of the area must be level, but it can slope parallel to the centerline. Place two of the main truss assemblies on the ground parallel to the centerline of the tramway, centered in the 20-foot length of the clearing, and 6 feet apart. Lay out two of the DB–1 and two of the DB–2 diagonal bracing trusses on the ground (fig. 114) and connect them together with hinge pins. Temporarily support the two main truss assemblies upright and hook the holes in the crossmembers of the diagonal braces over the pins pointing up on the bottom chord of the main truss assemblies. Hook the three lateral trusses in an upright position over pins on the bottom chord of the main truss and attach them with pins through the top chord. One lateral truss is placed at the center and one at each end of the framework (fig. 115) making up a box with an open top. Bottom

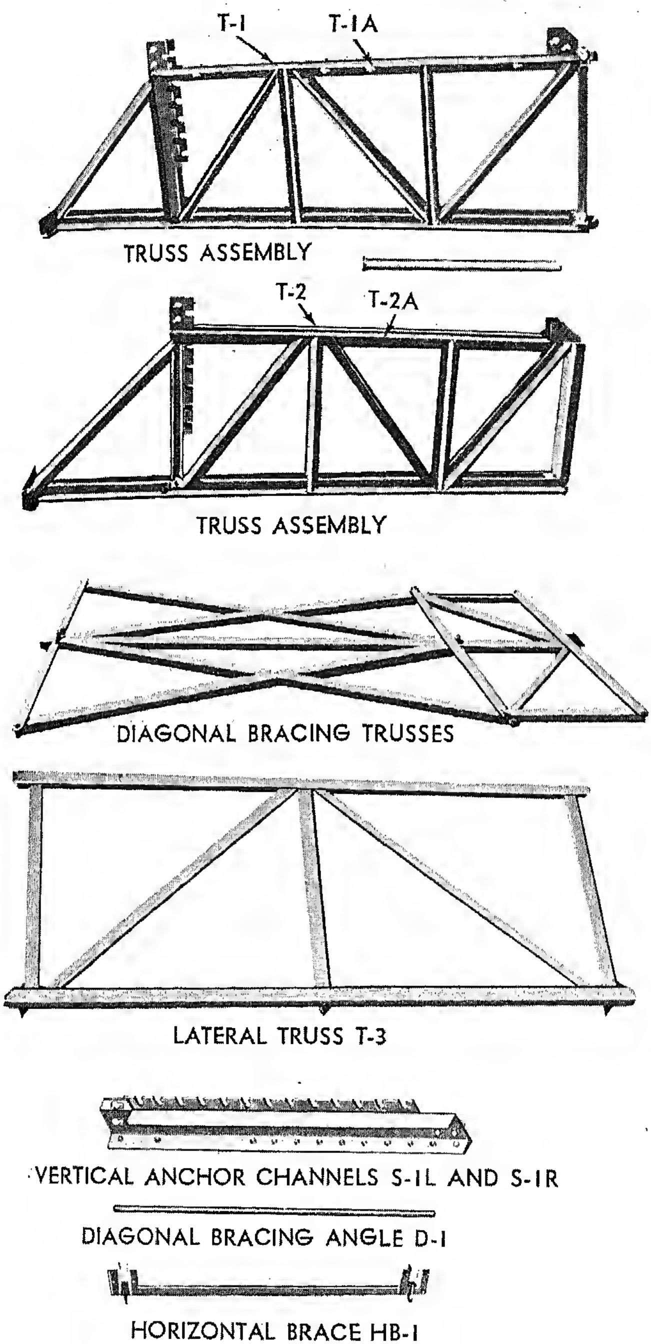


Figure 113. Terminal components.

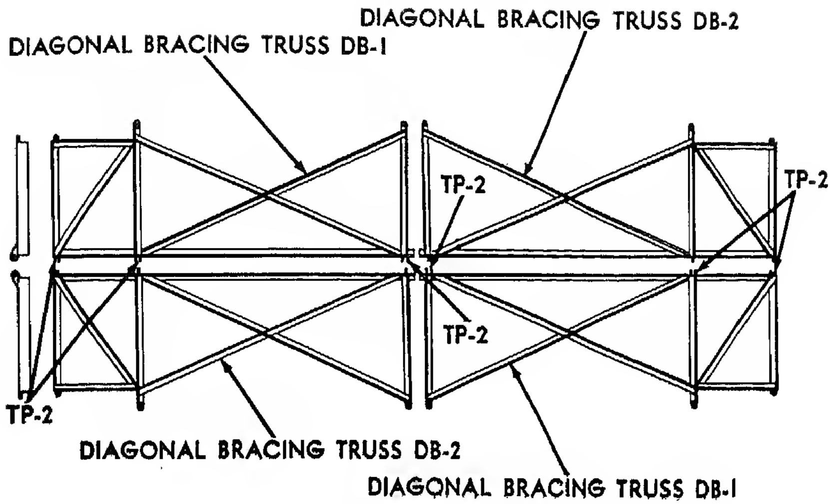


Figure 114. Layout of horizontal diagonal braces.

chord planking is included in the set. Each unit consists of two 2- by 8-inch planks, 10 feet long, bolted together with cleats. Place this bottom chord planking through the framework of the terminal over the bottom chord of the main truss assemblies so that it projects 2 feet on each side. Place about 12 tons of rock ballast (fig. 98) on this bottom chord planking to hold the terminal down. There are four S–1L and four S–1R vertical anchor channels (fig. 113) in the set. Attach one of each to the end of each main truss assembly facing the other terminal of the tramway. Bolt the horizontal brace across the top of the four vertical anchor channels. Place one diagonal bracing angle from the top of each vertical anchor channel back to one of the truss sections. The vertical anchor channels and diagonal bracing angles have slotted holes and cone-headed rivets in their ends. The rivets are inserted through the round part of the holes and moved down into the slots to lock the joint. This completes the basic terminal erection. At the upper terminal install the haul rope anchor assembly (fig. 116) by hooking its anchors in the notches in the vertical anchor channels. For the lower terminal (fig. 117), several components must be added to the basic terminal framework, including the power unit, weight box, and weight box mast assembly.

141. Weight Box Mast Assembly

The weight box mast assembly is used only at the lower terminal. Place the two pins on the top of the two lower sections (fig. 118) in the pipe sleeves of the center splice frame. The open end of the hooks on the center splice frame should point upward. The sheaves at the bottom, or pointed end, of the lower sections should be on the

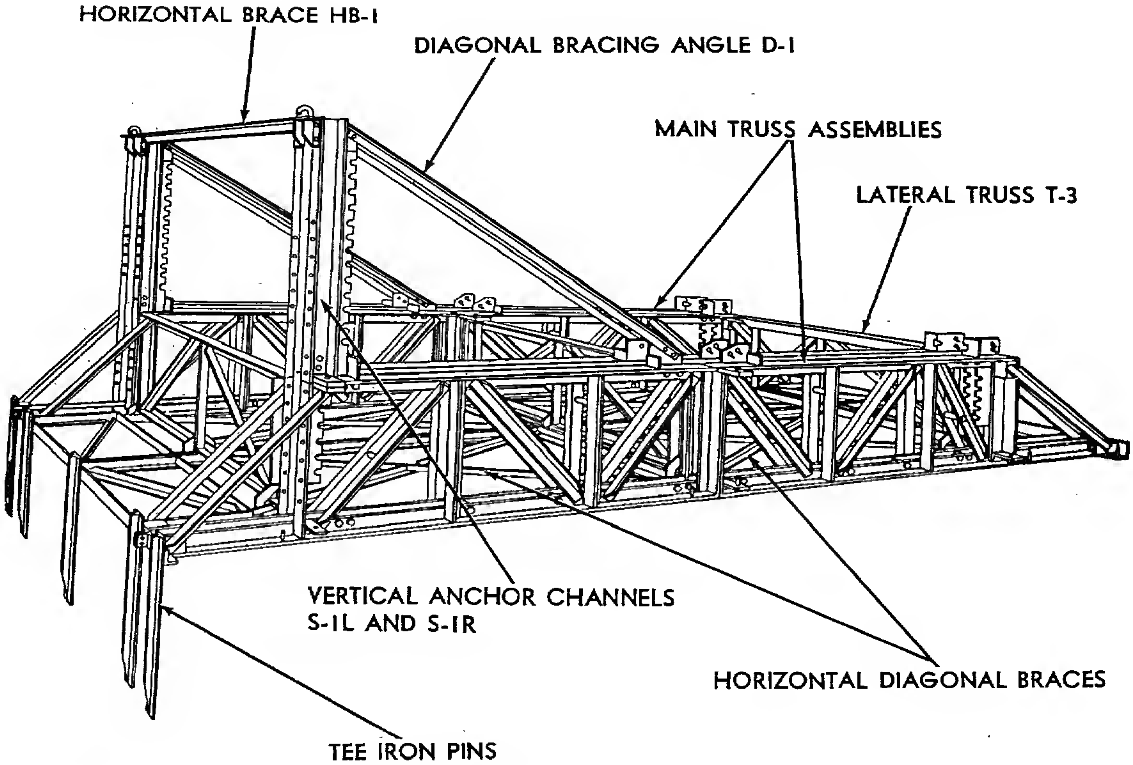


Figure 115. Basic terminal framework.

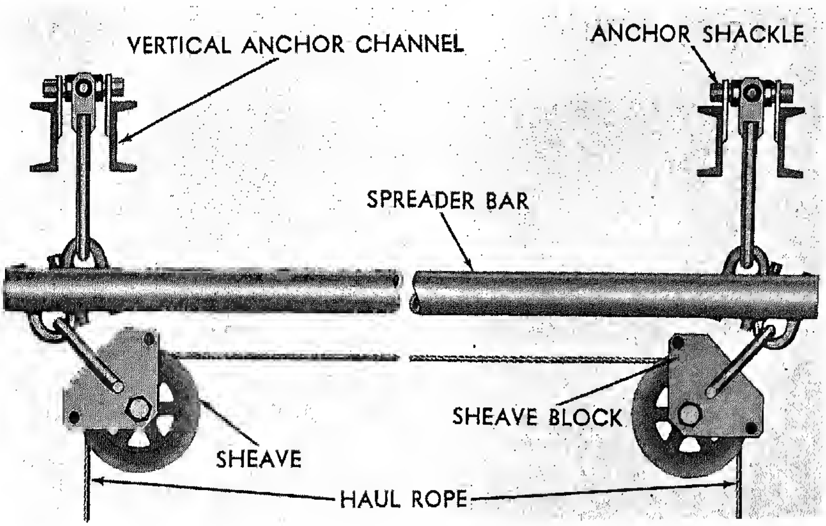


Figure 116. Haul rope anchor assembly.

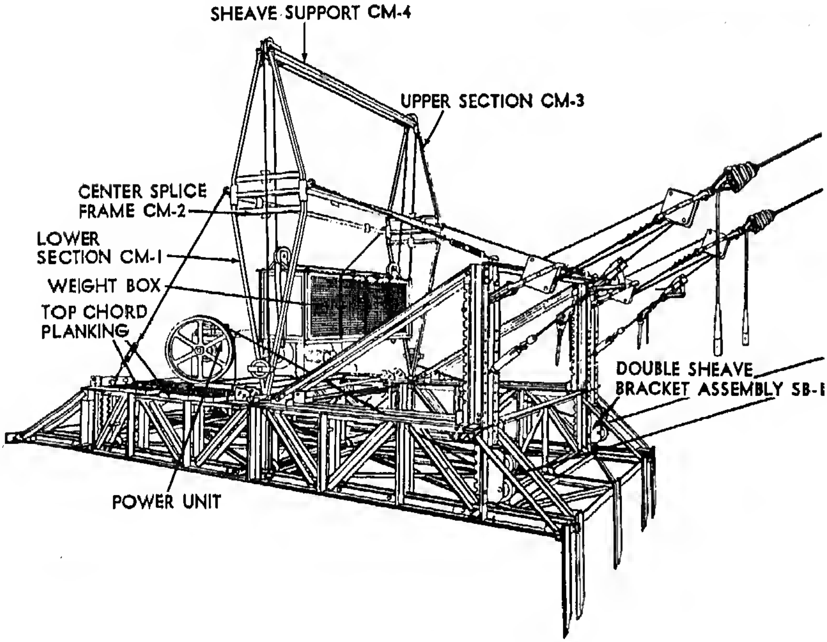


Figure 117. Lower terminal framework.

outside. Set these components in place on the lower terminal (fig. 117) with the pins at the bottom of the lower sections resting in the sockets at the centers of the main truss assemblies and support them in an upright position. Rig the guylines. Four guylines made of

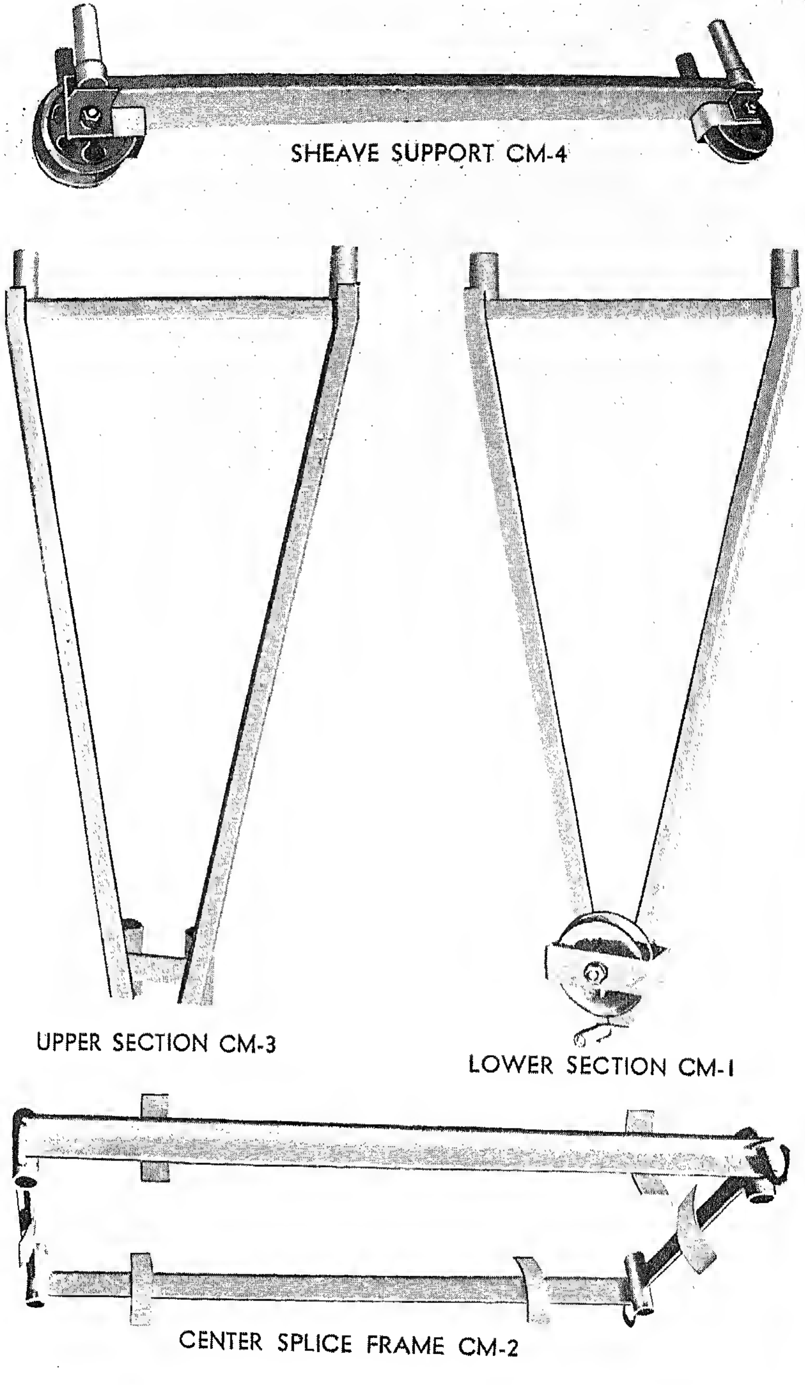


Figure 118. Weight box.

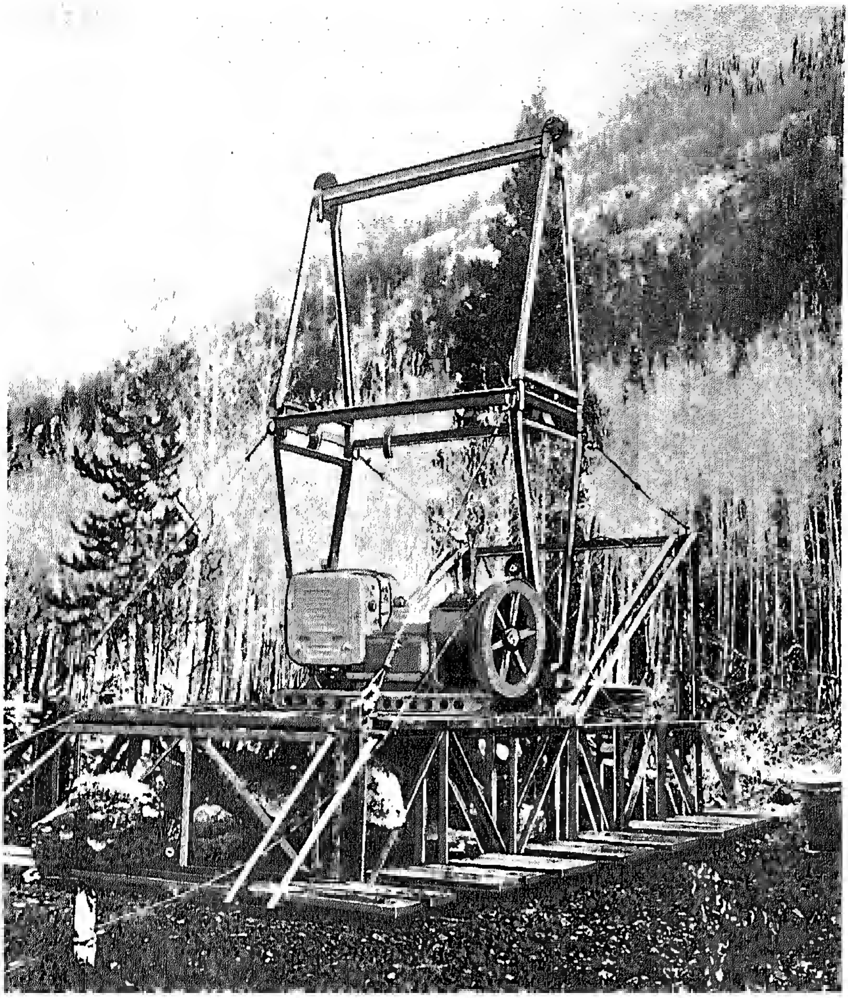


Figure 119. Lower terminal with weight box mast assembly and power unit in place.

¼-inch diameter wire rope are used. Place a turnbuckle in each guyline for minor adjustments. Place the upper end of each guyline over one hook on the center splice frame. Attach the lower end of the two front guylines to the hooks on the end of the horizontal brace bolted to the vertical anchor channels. Attach the lower end of the two back guylines to the vertical anchor channel brackets at the rear end of the two main truss assemblies. Slip the two pins at the bottom of the upper section in the top of the pipe sleeves on the center splice frame. Place the sheave support across the top with the pins on the sheave support in the pipe sleeves at the top of the upper section. The weight box mast assembly (fig. 119) is now complete, but must be plumbed. It is essential that this assembly

stand in a vertical position during operations. Use a level to check this and adjust the guylines as necessary to make it vertical.

142. Weight Box

The weight box (fig. 120) is a rectangular box 4 feet long, 2 feet deep, and 1 foot 3 inches wide. It is assembled from two weight box sides, two weight box ends, a weight box bottom, and a weight box crosstie. The sides, ends, and bottom have piano hinge connections, and eight hinge pins are used to fasten them together. The crosstie is pinned in place. Set the weight box in position temporarily under the weight box mast assembly, but do not ballast it.

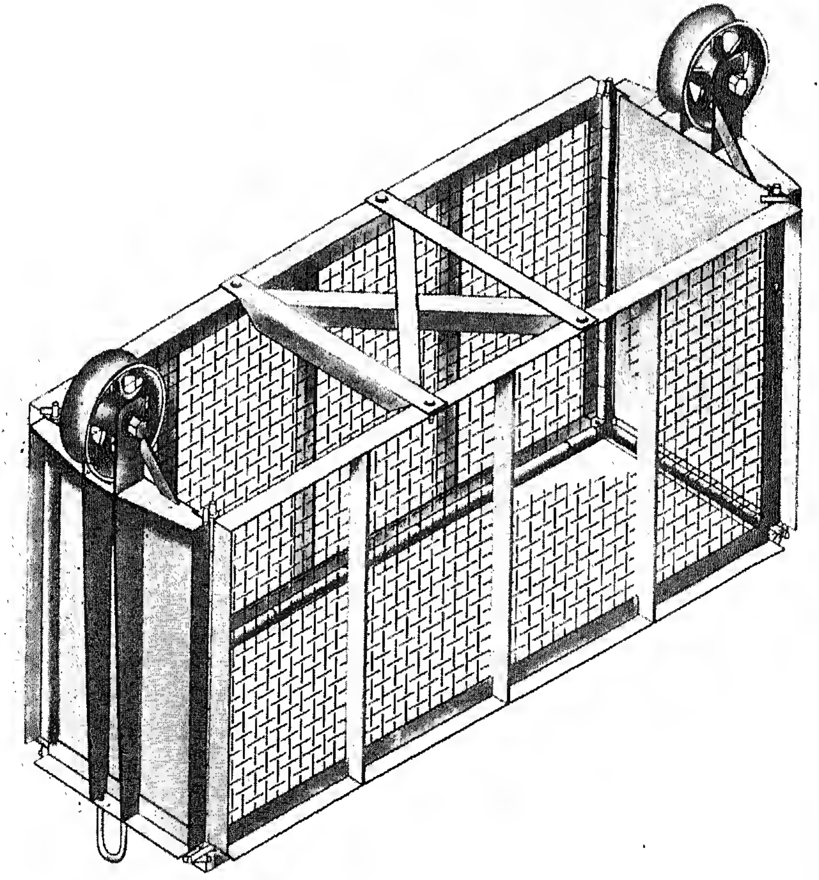


Figure 120. Assembled weight box.

143. Power Unit

Two units of top chord planking are supplied in the set. Each unit consists of four 2- by 8-inch planks, 7 feet long bolted together. Place these two units on top of the top chord of the main truss assemblies and hook them in place by securing the cone-headed rivets in the matching notches. Place the power unit on the top chord planking (fig. 119) just behind the weight box mast assembly with the drive spool in line with the sheave at the base of one lower section.

144. Track Cables

a. Stringing Cable. The track cable is on reels of 500 feet each. During the time that the towers and terminals are under construction, the track cables can be strung along the route. Assign a crew of men to distribute the reels at intervals of approximately 500 feet. Starting at the lower terminal, place one reel on the cable reel turntable (fig. 121) and drag the end by manpower up the right-of-way. Move the turntable up to this new position and set the second reel on it. Pull the end of the second reel up the slope and connect the downhill end to the uphill end of the first section. A special fitting is attached to the track cable for this purpose. Each end of the track cable has a zinced-in fitting with a female thread on it (B, fig. 122). A coupling plug is provided with a right-hand thread on one end and left-hand on the other. To a
two couplings together with the coupling plu
cause of the reverse threads, turning the coupling plu
plug into the couplings, bringing them together. When t
pieces are against the collar of the plug, insert a coupling
each coupling piece and peen the ends to lock the joint. In some

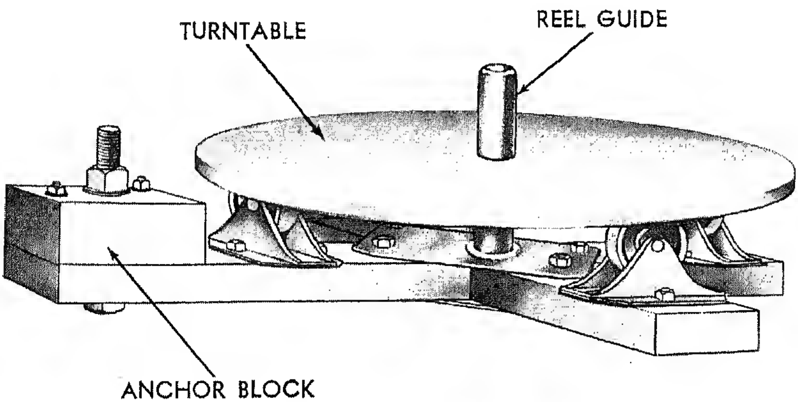


Figure 121. Cable reel turntable.

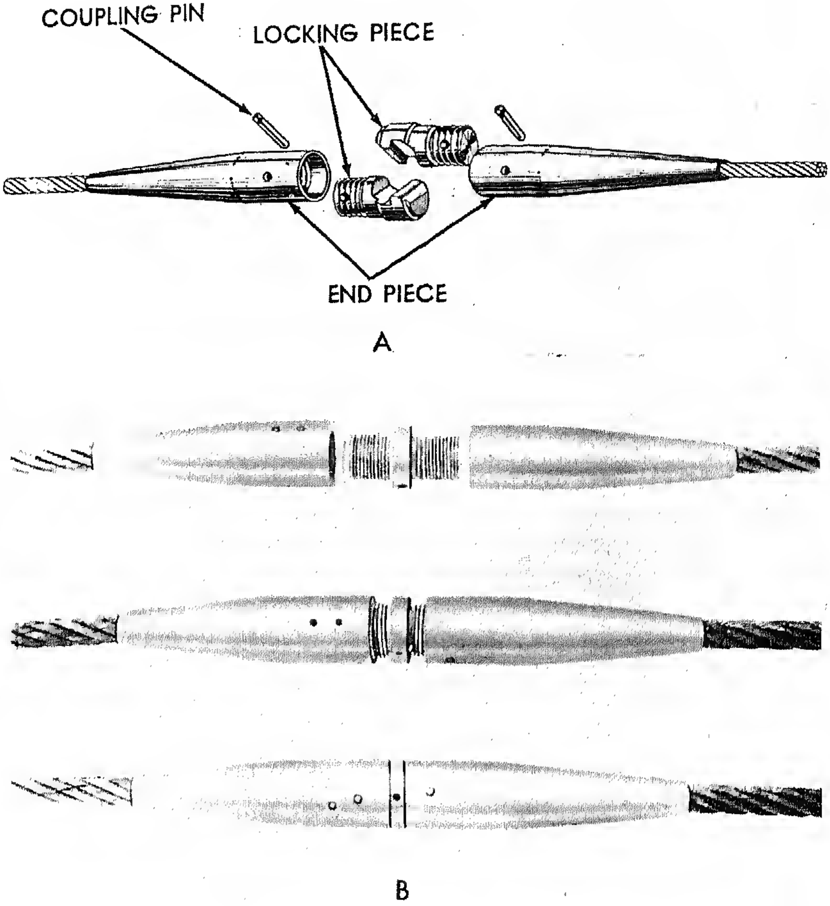


Figure 122. Wire rope coupling assembly.

sets the locking plug consists of two pieces (A, fig. 122) with the thread on one end and a locking jaw on the other. To assemble a coupling, fit the jaws of two locking pieces together and screw them into the coupling pieces. The couplings are furnished with coupling pins in the same manner as the other type of coupling plug. Continue the stringing of the cable, moving up one reel at a time. When an intermediate tower is passed, the track cable must pass through the main bent or be lifted into the bent before it is completed. If the tower is complete pull the end of the track cable through the main bent and let it move across the idler sheave for the rest of the stringing of that reel. If a stream must be crossed, place the cable reel turntable in a boat and pay the cable out over the stern as the boat crosses the stream. Both track cables must be strung out, but care should be taken to avoid any entangling of the two.

b. Upper Terminal Connection. At the upper terminal, couple the end piece of the last reel of track cable strung to an anchor end piece with two coupling locking pieces and coupling pins as before. The anchor end piece has a short crossbar on it. Turn this crossbar sideways and insert it between two vertical anchor channels (fig. 123) on the upper terminal. After it is inserted, turn the anchor end piece until the crossbar will fit into a pair of the notches in the vertical anchor channels. The slack in the line will be pulled out as installation progresses.

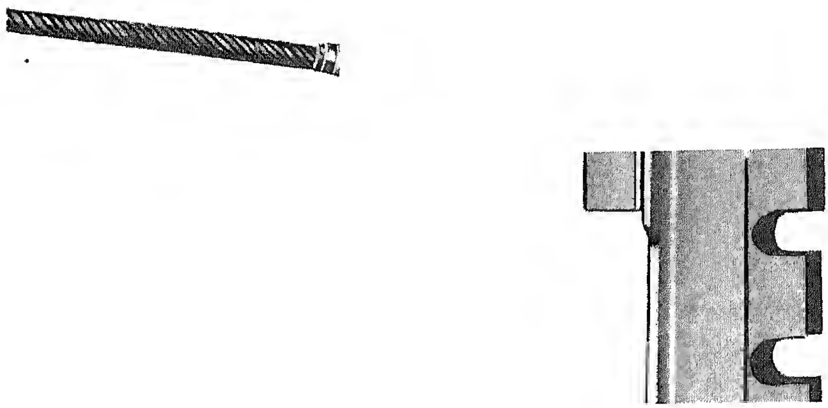


Figure 123. Track cable coupling of upper end.

c. Tower Connections. At each intermediate tower, install the track cable in the track cable hanger assembly after pulling as much slack as possible out of the track cable. Start at the tower nearest the upper terminal and move toward the lower terminal. The track cable can be lifted by passing a fiber rope over the top angle crossmember and pulling the track cable up. Remove the two clamp bolts (fig. 112) and the clamp from the track cable saddle. Grease the groove in the saddle, install the clamp and clamp bolts, and tighten the clamp bolts. If the connection at a track cable hanger should fall at a coupling in the track cable, disconnect the last preceding coupling and insert an adjustment assembly. An adjustment assembly is a 25-foot length of track cable made up with end pieces. Two adjustment assemblies are included in the set.

d. Lower Terminal. At the lower terminal, takeup gear is installed to obtain the required tension on the track cables. There is one set of takeup gear for each track cable. For each set of takeup gear, lay out on the ground two double blocks some distance apart and reeve them with ¼-inch diameter wire rope. Attach the end of the wire rope to the becket of the block farthest from the lower terminal. After the blocks are reeved, the lead line will also leave this block. Attach a wedge-type cable grip to this block to receive the track cable. Connect the block closest to the lower terminal to an anchor shackle (fig. 124). Pass the crosspin of the anchor shackle between two vertical anchor channels on the lower terminal and turn it until the pins can be engaged in a pair of notches in the vertical anchor channels. Hook the crosspin at the end of a tensiometer to the lower terminal in the same manner (fig. 125) but far enough below the block to keep them from fouling. Hook one end of a lever operated chain hoist to the tensiometer. Extend the chain hoist fully and attach a "come-along" cable grip to the other end of it to receive the lead line from the tackle previously rigged. To connect the takeup gear, haul all possible slack out of the track cable by hand and place it in the wedge-type cable grip on the upper block of the takeup gear. Now haul on the lead line of this tackle by hand; removing as much additional slack as possible with this 5 to 1 mechanical advantage. Holding the strain on the lead line, attach the cable grip on the upper end of the lever operated chain hoist to the lead line. Operate the chain hoist to obtain the desired tension.

e. Track Cable Tension. The indicated tension on the tensiometer is the tension in the lead line of the tackle, which has a 5 to 1 me-

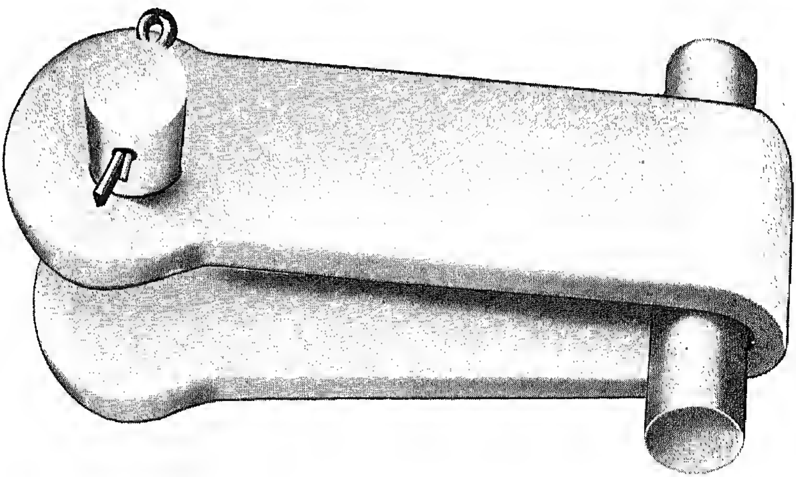


Figure 124. Anchor shackle for track cable.

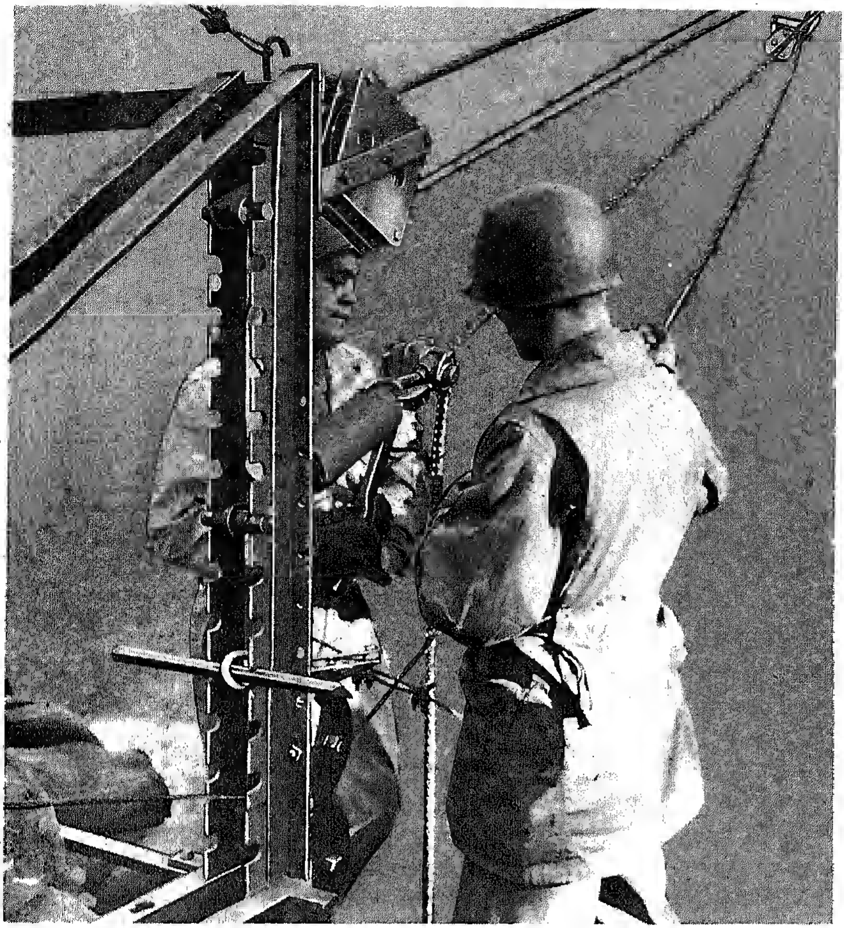


Figure 125. Takeup gear at lower terminal.

chanical advantage. The tension in the track cable is therefore five times the tension indicated by the tensiometer. This equipment normally is operated with 7,000 pounds of tension on the track cable (tensiometer reading of 1,400 lbs.). Some of the tensiometers issued do not have an indicator. On these tensiometers, the equivalent tension would be reached when the outer edge of the gage washer (fig. 126) and the tensiometer gage coincide. Track cable tension of 7,000 pounds was used to prepare the track cable deflections shown in figure 103.

f. Safety Ropes. As a safety device, safety ropes should be installed at each end of each track cable. Make the safety ropes from ½-inch diameter wire rope. Attach one end of the safety rope to the track cable above the point where it is connected to the terminal with four wire rope clips. Pull the safety rope as tight as possible and connect

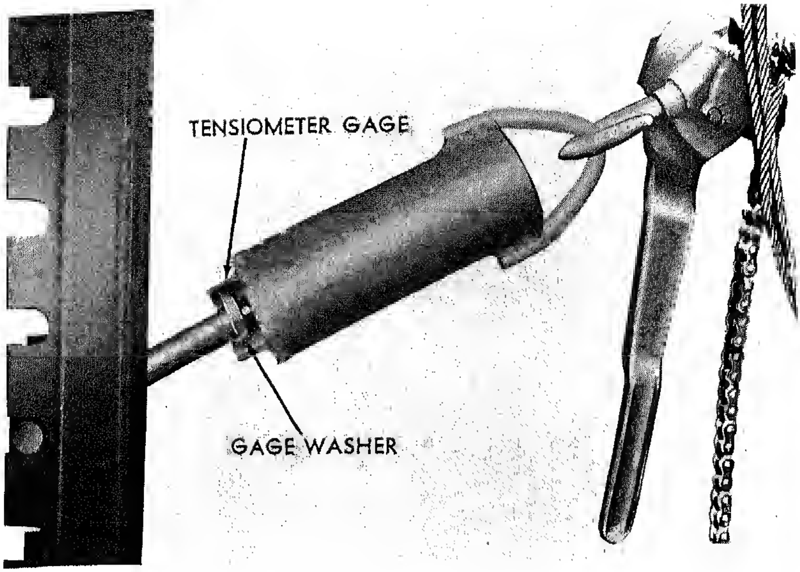


Figure 126. Track cable tensiometer.

it to a deadman under or behind the terminal. If any anchor gear should slip, the safety rope will prevent the track cable from falling.

145. Carrier Assembly

The carrier hanger assembly (fig. 101) has two sheaves to fit over the track cable. Attach two platform supports to the carrier hanger assembly and place a platform on them. Three types of platforms are supplied in the set. A short steel platform or a short wooden platform may be used. Longer wooden platforms are supplied for use in evacuating casualties. For such use, place two of the long wooden platforms on each carrier assembly, with the second platform supported across the center crosspieces of the platform supports. When available, Stokes-type litters should be placed on the platforms and tied down securely. For very long loads, such as pipe, two carriers can be placed on the track cable close together, one at each end of the load. In such case, the extra carrier is held in position by attaching two short pieces of haul rope to the carrier drawbar and fastening them to the main haul rope with wire rope clips. One platform support has adjustable sleeves for leveling the platform. This support should be placed on the uphill side. Make up two carrier assemblies and place one on each track cable. One carrier assembly is placed at the upper terminal and the other at the lower terminal. Fasten a temporary tag line on each carrier and tie it in place. The trolley of the carrier must set on the track cable so that it will pass the track cable hangers.

146. Haul Rope

a. Description. The haul rope is ¼-inch diameter 6 x 7 wire rope made up on reels with 1,500 feet in each reel. Eight reels are supplied. Slightly over 6,000 feet would be required for a tramway length of 3,000 feet. No end fittings are supplied for the haul rope. Joints must be made up by splicing the rope where required. Refer to TM 5–725 for detailed methods of splicing wire rope.

b. Stringing Haul Rope. Starting at the lower terminal, string out two lengths of haul rope. To do this, place the reel on the cable reel turn-table (fig. 121) or on a mandrel supported by jacks, and pull the end uphill. As each intermediate tower is passed, put the end of the haul rope through the main bent over the idler sheave and continue pulling. One length of haul rope is pulled up through one set of towers and the other length through the remaining set of towers. On long spans, when the end of the rope comes off the reel, splice it to the end of a second reel and continue pulling.

c. Upper Terminal. At the upper terminal a carrier assembly is on one track cable (para. 145). Pass the end of the haul rope which goes with the other track cable through the sheaves of the haul rope anchor assembly (fig. 116) on the upper terminal. Then fasten this end to the uphill side of the drawbar (fig. 101) on the carrier assembly, using wire rope clips to hold the end. Fasten the end of the haul rope which goes with the track cable holding the carrier assembly to the downhill side of the drawbar on the carrier assembly in the same manner.

d. Lower Terminal. At the lower terminal, tie the weight box to the sheave support on the weight box mast assembly with fiber rope. Bolt the two double sheave bracket assemblies (fig. 127) in place on the vertical anchor channels at the front of the lower terminal. One double sheave bracket assembly is bolted on each side. The haul rope connected to the downhill side of the carrier assembly at the upper terminal must now be rigged through the lower terminal. Pass the end through the double sheave bracket assembly, around the idler sheave at the base of the weight box mast assembly (fig. 128) and up to the idler sheave on the sheave support. Run this end through the sheave on the same side of the weight box, across the top of the weight box to the other sheave, and up to the remaining sheave on the sheave support. From this upper idler sheave, bring the haul rope down around the idler sheave at the bottom of the weight box mast assembly on this side and around the drive spool of the power unit. The haul rope goes on at the bottom of the drive spool, makes 2½ turns about the drive spool, coming off the top to the remaining double sheave bracket assembly at the front of the lower terminal. Haul as much slack as possible out of the other side of the drawbar on the carrier assembly. Remove the slack (*e* below) from the line which has been

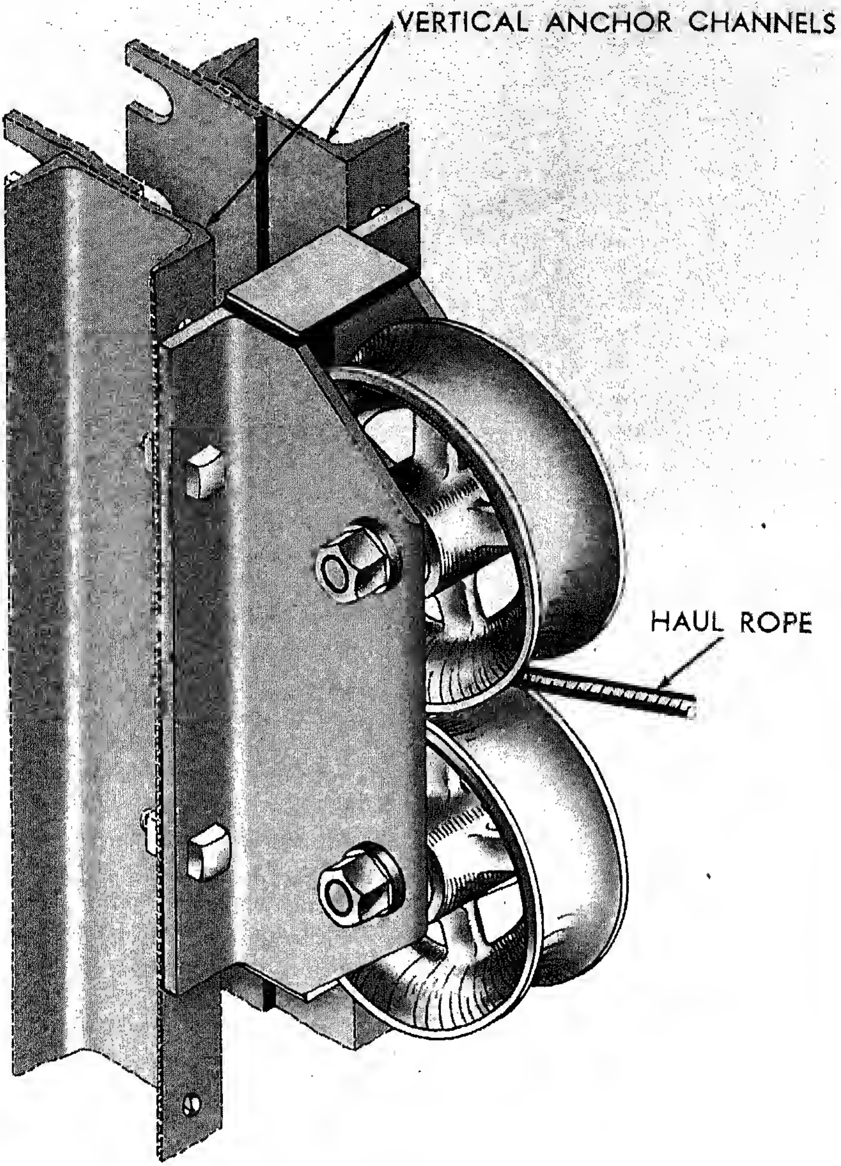


Figure 127. Double sheave bracket assembly.

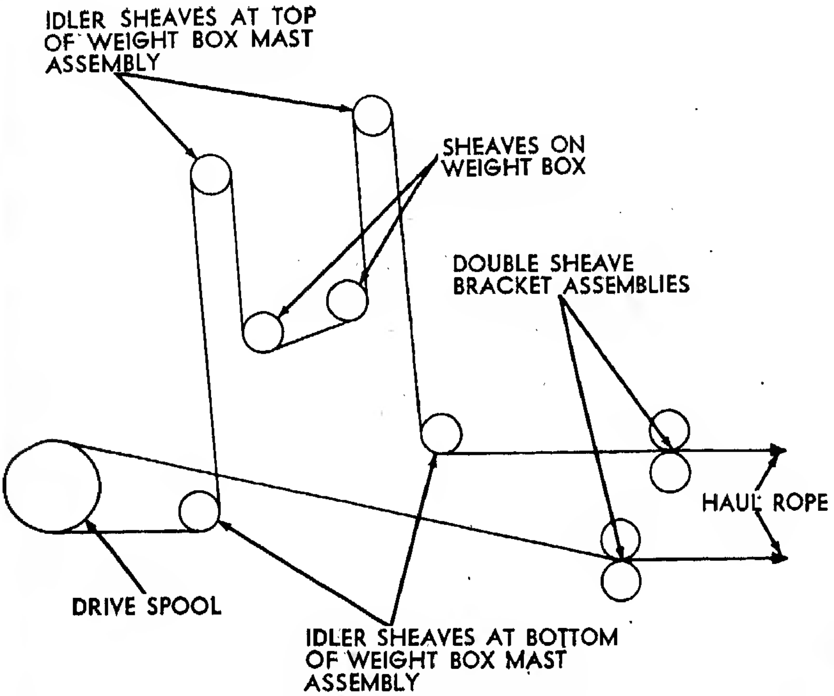


Figure 128. Schematic diagram of hand rope rigging at lower terminal.

reeved through the weight box mast assembly and fasten the end of it to the downhill side of the drawbar on the carrier assembly.

e. Removing Slack. Before the final connection of the haul rope is made to the carrier assembly, the slack should be removed from the line. It is easier to use the power unit to do this. Place two temporary ties on the bottom of the weight box to prevent it from moving further upward. Station two men on the free end of the haul rope ahead of the lower terminal to maintain tension. Start the power unit and slowly engage the clutch. Great care must be used to avoid damage to components. Tighten the haul rope until there is enough tension to prevent slippage on the drive spool and connect the free end to the carrier assembly. Remove the temporary ropes from the weight box and load it with rock or sandbags. The weight box should be heavy enough to maintain tension in the haul rope (fig. 129) and should ride at the midpoint of the weight box mast assembly in operation. Tie ropes to the U-bolts in the bottom of the weight box just long enough to prevent the weight box from colliding with the sheave support when it rises as a load is applied to the haul rope.

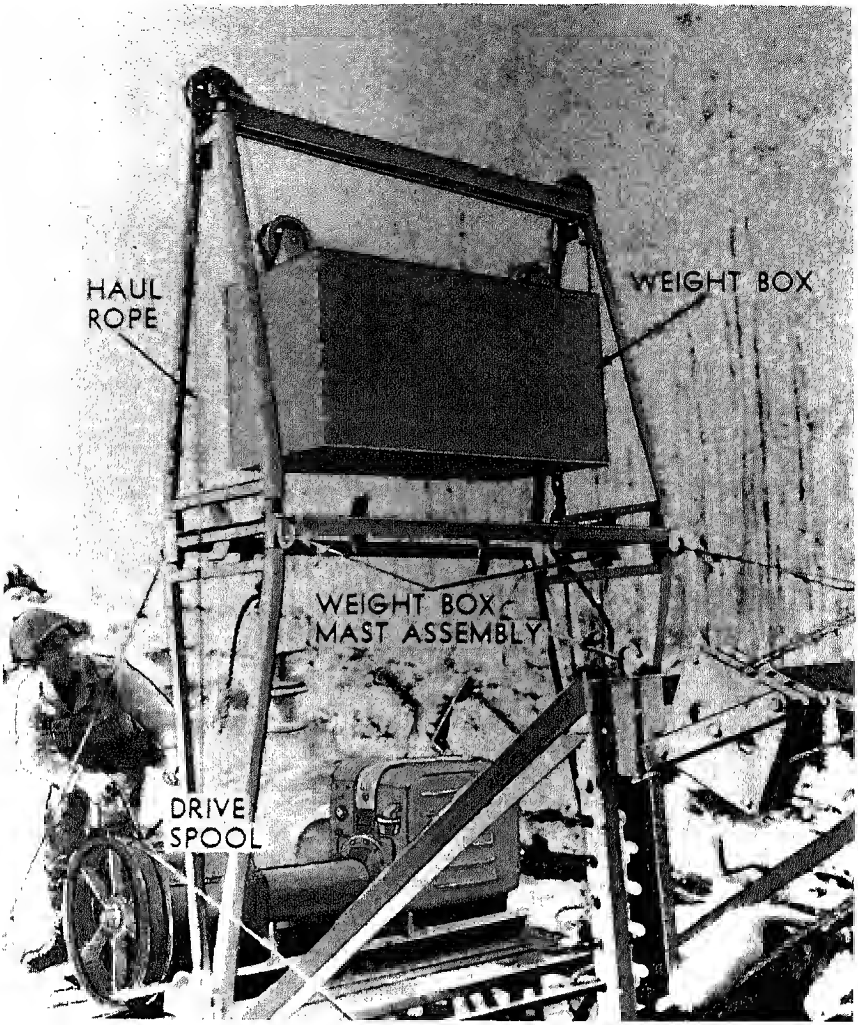


Figure 129. Weight box in operation.

Section IV. OPERATION

147. Operating Crew

Eleven men are needed for normal operation of the M2 tramway. One man is stationed at the power unit as an operator. The remaining 10 men are split into 2 crews of 5 men each. One 5-man crew is stationed at each terminal for loading and unloading carriers.

148. Night Operation

Night and blackout operation reduce the speed with which men can load and unload the carriers but not the speed of operation of the

equipment. However, the power unit operator cannot see the position of the carriage nor the progress of loading or unloading. To compensate for this, telephone communication is necessary. Field telephones provided in the set are used. One telephone at the loading position, one at the unloading position, and one at the power unit are usually adequate.

149. Power Unit

The power unit supplied for the medium cableway and the M1 and M2 tramways is identical. Refer to paragraph 121 for general operating instructions on this power unit. Detailed operation and maintenance instructions for the power unit are covered in TM 5-9157.

150. Adjustments

When the installation is completed, trial runs should be made and the haul rope and track cable should be checked and adjusted. New wire rope will stretch considerably in use. For the first few days the haul rope and track cable tension should be checked frequently and adjusted if necessary. For the trial runs, station a man at each intermediate tower and provide communication with the power unit operator to prevent damage. During the trial runs, personnel at the towers should carefully observe the action of the haul rope in the idler sheaves. The power unit operator should observe the drive spool carefully for evidences of slippage. If slippage occurs the haul rope tension must be increased enough to prevent it. Add weight to the weight box to increase tension. The tension in the haul rope should never be great enough to cause it to rise above the track cable at any point as this would cause chafing and excessive wear. After unloaded trial runs have been made, a loaded trial should be made. Place the maximum load in the carriers and carefully observe all critical points along the route for clearance as well as for the same conditions observed during the unloaded trial runs. There should be a slight downward pressure of the track cable on the saddle of the track cable hanger at each intermediate tower. If the track cable shows enough tendency to lift to be retained in the saddle only by the clamp, the height of the track cable hanger at that tower must be increased to overcome it.

Section V. MAINTENANCE

151. Care in Handling

To attain maximum performance the equipment must be handled with care. Frequent lubrication will extend the life of the components. Smooth stopping and starting of loads will reduce the stress on the carriers and cables. The haul rope must not run faster than

350 feet per minute. When personnel are riding, they should seat themselves on the bottom of the carrier facing the direction of travel. Passengers must be warned not to let the carrier start swinging and not to permit arms or legs to protrude outside the carrier. The power unit operator must exercise great care to start and stop the carriage smoothly when hauling personnel. Bundled or packaged loads should be tied in place on the carrier.

152. Inspection

Inspect all components and fittings at frequent intervals. Examine guylines and anchorages, anchor slings, track cable, and haul rope. Tighten loosened wire rope clips. Inspect wire rope carefully for worn or broken wires. Replace any wire rope which shows signs of cutting. Remove and straighten any bent or deformed parts on the towers, terminals, carriers, or track cable hangers to prevent increased damage and unsatisfactory operation. Refer to TM 5–725 for detailed instructions on care of rigging.

153. Lubrication

All blocks and sheaves must be lubricated at frequent intervals, the exact frequency depending on the amount of use. The components issued with the set are heavy duty units. If standard issue blocks are used at any point, a grease fitting should be installed and the block should be greased very frequently, as much as once per trip in some cases, to prevent cutting. It has been found that most failures in service of these units are caused by lack of adequate lubrication. Particular attention must be given to the lubrication of the power unit. Detailed lubrication instructions on the power unit are covered in TM 5–9157. Wire rope should be lubricated carefully at intervals to reduce deterioration. Refer to TM 5–725 for instructions on the lubrication of wire rope.

154. Painting

Most of the steel work of the tramway is protected by paint which should be renewed whenever inspection reveals the need. Chipping, scaling, or blistering of the paint should be corrected by cleaning off the old paint and applying a rust preventive compound and a fresh coat of paint.

CHAPTER 9

AERIAL CABLEWAY SET, 3,000-POUND

Section I. INTRODUCTION

155. Characteristics

The aerial cableway set available as an issue set, provides a means of transporting loads up to 3,000 pounds over streams, gorges, or marshes with a maximum length of 1,200 feet between towers. It has a line speed of 550 feet per minute. Capacity over a 1,000-foot gap is 17 tons per hour, allowing a loading and unloading time of 1 minute for each crossing.

156. Equipment

The list in table XIII shows the cableway components included in the set.

Table XIII. Components Included in Set for Medium Cableway

Item	Quantity
Anchor assembly, hand winch	2
Angle, splice, tower	72
Block, tackle:	
1½-ton, ½-in. wire rope	11
3-ton, ⅜-in. wire rope	1
4-ton, ⅜-in. wire rope	1
7-ton, ½-in. wire rope	2
Cap, stake driving	25
Carriage assembly	1
Chain assembly, single leg	1
Clip, wire rope:	
⅜-in. dia	152
½-in. dia	159
⅞-in. dia	32
Drive unit, aerial tramway-cableway	1
Fitting, lubrication	24
Grip, cable, jaw	2
Keeper assembly	2
Lumber, softwood, timber	48
Nut, self-locking, hexagon	800

Table XIII. Components Included in Set for Medium Cableway—Continued

Item	Quantity
Pin, base plate, tower	2
Pin, cotter	204
Pin, coupling	24
Plate, base, tower	2
Plug, coupling	1
Screw, cap, hexagon head	600
Shackle:	
Anchor	50
Chain	2
Sling, multiple leg:	
⅜-in. chain	3
½-in. chain	3
Socket, socket wrench	16
Socket, wire rope	10
Stake, anchor	100
Thimble, rope:	
⅜-in. dia	4
½-in. dia	21
⅞-in. dia	4
Tower section, intermediate	14
Tower section, pivoted	2
Tower section, top	2
Turnbuckle	7
Washer, flat:	
¾-in. bolt size, 2-in. dia	2
1⅜-in. bolt size, 3¼-in. dia	3
Winch, drum, hand operated	2
Winch, drum, power operated	1
Wire rope, steel:	
⅜-in. dia, 40-ft unit length	10
⅜-in. dia, 150-ft unit length	4
⅜-in. dia, 1,700-ft reel	1
⅜-in. dia, 3,000-ft reel	1
⅜-in. dia, 40-ft unit length	7
½-in. dia, 300-ft unit length	5
½-in. dia, 400-ft unit length	1
½-in. dia, 60-ft unit length	1
⅞-in. dia, 50-ft unit length	2
Wire rope assembly, single leg:	
Zinced-in coupling piece, left-hand	1
Zinced-in coupling piece, right-hand	1

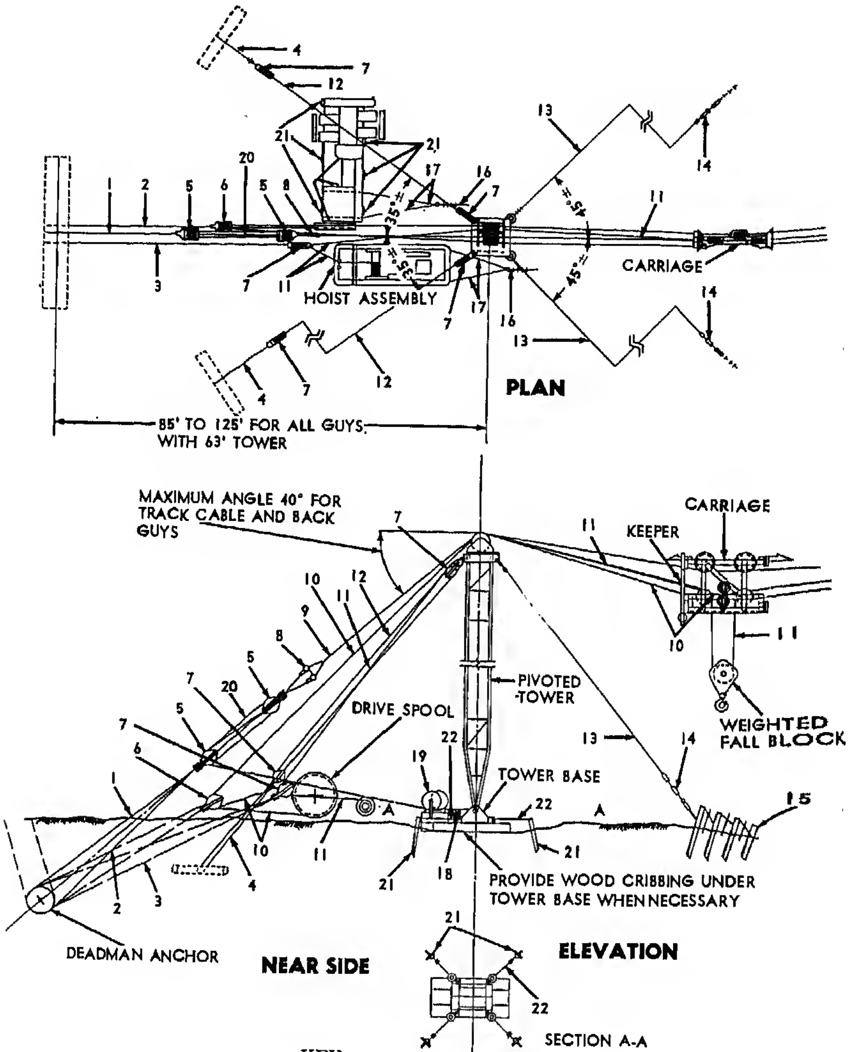
157. Description

a. General Design. The cableway consists of a ⅞-inch diameter track cable suspended between two towers. Towers are assembled from prefabricated sections. The bottom section is pivoted about a horizontal pin. Sections are assembled together to produce the height required for the carriage to clear at all points. The tower is then

hoisted into position, pivoting about the pin at the base, and secured in place by guylines. The track cable is anchored (fig. 130) behind each tower. A traveling carriage, suspended from the track cable, is moved back and forth across the span by a continuous haul rope. The haul rope is controlled by a gasoline-engine-driven spool. A fall rope, reeved through the carriage and a weighted fall block, enables loads to be raised or lowered as desired and held aloft while traveling across the span. The fall rope is operated by a gasoline-engine-driven drum hoist.

b. Towers. Two towers, one for each terminus of the span, support the track cable and provide ground clearance for the carriage. Each tower is composed of a base plate, a pivoted tower section fastened to the base plate with a base plate pin, intermediate tower sections, and a top tower section. There are seven intermediate tower sections in the set for each tower, and any number of sections can be used, up to the maximum tower height of 71 feet 9⅜ inches. The base plate is 2 feet square and weighs 145 pounds. The pivoted tower section is 7 feet 4½ inches long, weighs 150 pounds, and is tapered toward the base plate. The base plate pin weighs 14 pounds and is 2 feet 4 inches long. The intermediate tower sections are of rectangular cross-section, weigh 165 pounds each, and are each 8 feet 9½ inches long. The top tower section includes the sheaves over which the track cable, haul rope, and fall rope pass. It weighs 285 pounds and has two links at each of its four corners for attaching guylines. A splice angle is bolted at each corner of each joint during erection to connect the tower sections. Each splice angle is 2½ x 2½ x ⁵⁄₁₆ inches, weighs 5 pounds, and is 1 foot 7 inches long. Figure 131 illustrates the components of a tower.

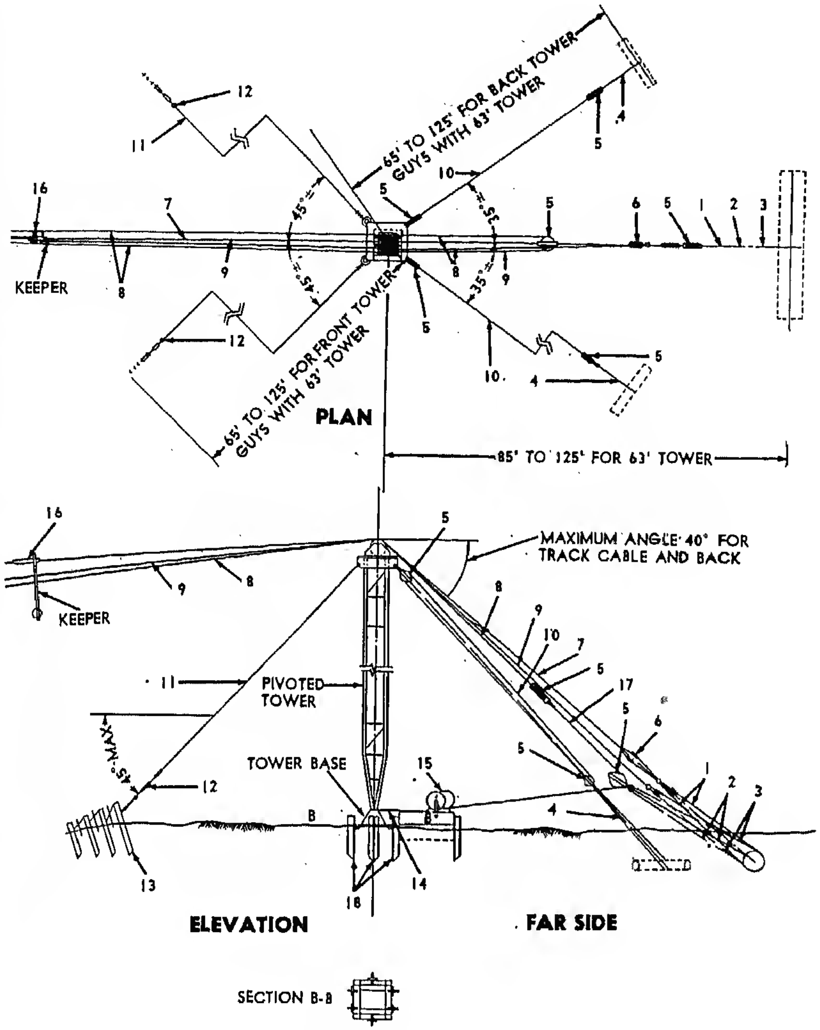
c. Track Cables and Haul Rope. The track cable is in two 750-foot lengths of ⅞-inch diameter, 6 x 19, IPS wire rope with an independent wire rope center. Each 750-foot length is coiled on a reel. A wire rope coupling piece is fastened to one end of each 750-foot length. The cable is coiled on one reel so that the coupling piece is inside the coil and on the other reel so that the coupling piece is outside the coil. A coupling plug is provided with a right-hand thread on one end and a left-hand thread on the other end for joining the two coupling pieces. The coupling pieces are made of steel with a maximum diameter of 2⅛-inches tapered down to the diameter of the track cable to permit the sheaves of the carriage to ride over the coupling without leaving the cable. The cable is fastened into the small end of the coupling piece with zinc. The track cable is marked every 50 feet with painted red bands to simplify centering the coupling in the span. To assemble the coupling (B, fig. 122), bring the two coupling pieces together with the coupling plug between them. Because of the reverse threads, turning the coupling plug screws the coupling pieces on it and brings them together. When both coupling



KEY

1. TWO PARTS ⅞-INCH CABLE FOR TRACK CABLE ANCHOR.
2. TWO PARTS ½-INCH CABLE FOR HAUL ROPE ANCHOR.
3. TWO PARTS ½-INCH CABLE FOR FALL ROPE ANCHOR.
4. TWO PARTS ½-INCH CABLE.
5. TRIPLE BLOCK.
6. DOUBLE BLOCK.
7. SINGLE BLOCK
8. CABLE GRIP, WEDGE TYPE.
9. ⅞-INCH TRACK CABLE, 6 x 19, 750 FEET.
10. ¾-INCH HAUL ROPE, 6 x 19, IPS.
11. ⅜-INCH FALL ROPE, 6 x 19, IPS.
12. ½-INCH GUY CABLE, 6 x 19, IPS 300 FEET.
13. ⅝-INCH GUY CABLE, 6 x 19, IPS.
14. ⅝-INCH WEDGE SOCKET, ¾-INCH J AND E TURNBUCKLE.
15. STEEL PICKET HOLDFAST.
16. HOLDFAST.
17. ¾-INCH CABLE SLING.
18. HAND WINCH ANCHOR ASSEMBLY.
19. HAND WINCH, 5-TON.
20. ½-INCH CABLE, 6 x 19, 400 FEET.
21. STAKES.
22. 2 PARTS ¾-INCH CABLE.

Figure 130. Layout of cableway, guylines, anchorages, and power unit.



KEY

1. TWO PARTS ⅞-INCH CABLE FOR TRACK CABLE ANCHOR.
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3. TWO PARTS ½-INCH CABLE FOR FALL ROPE ANCHOR.
4. TWO PARTS ½-INCH CABLE.
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6. CABLE GRIP, WEDGE TYPE.
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9. ⅜-INCH FALL ROPE, 6 x 19, IPS.
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11. ⅜-INCH GUY CABLE, 6 x 19, IPS.
12. ⅜-INCH WEDGE SOCKET, ¾-INCH J AND E TURNBUCKLE.
13. STEEL PICKET HOLDFAST.
14. HAND WINCH ANCHOR ASSEMBLY.
15. HAND WINCH, 5-TON.
16. WIRE ROPE COUPLING.
17. ½-INCH CABLE, 6 x 19, IPS, FOR ADJUSTING TENSION IN HAUL ROPE.
18. STAKES.

Figure 130—Continued.

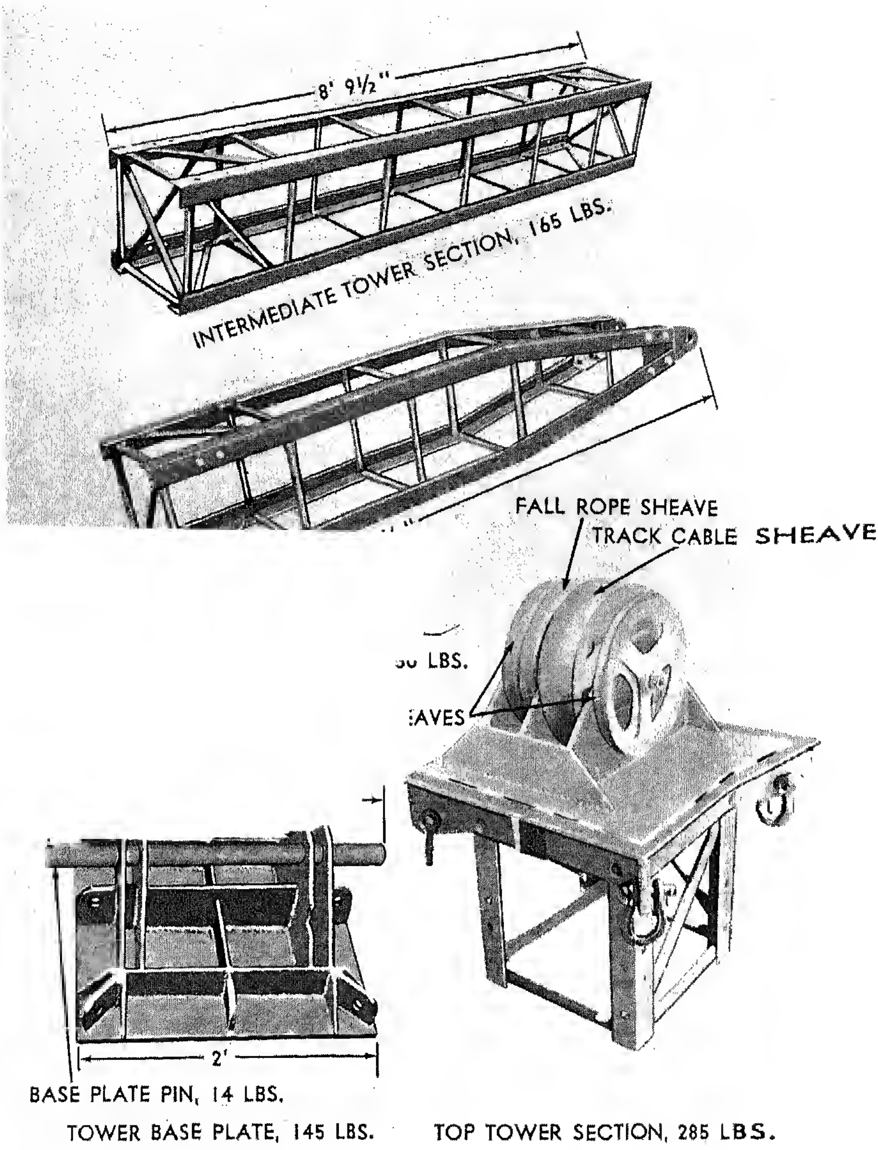


Figure 131. Components of a tower.

pieces are against the collar of the coupling plug, insert a coupling pin through each coupling piece and peen the ends to lock the joint. Spare pins are supplied with the set. A 1,700-foot length of ⅜-inch diameter, 6 x 19, IPS wire rope with hemp center is supplied with the set for use as a fall rope. A 3,000-foot length of ⅝-inch diameter,

6 x 19, IPS wire rope with hemp center is supplied with the set for use as a haul rope.

d. Carriage. A carriage is provided in the set for the cableway with two keepers (fig. 132) and a fall block. The carriage weighs 350 pounds but the weight can be reduced to 200 pounds, for transportation, by removing the sheaves and spears. There are two track sheaves on the carriage to support it on the track cable. Two fall-rope sheaves and two idler sheaves are mounted on the carriage to guide and support the fall rope and haul rope. There are two wedge sockets on the carriage for fastening the ends of the haul rope to it. The keepers ride on the track cable on rollers and each keeper has three sheaves. The center sheave supports the fall rope and the two outer sheaves support the haul rope. Each keeper weighs 50 pounds. When the carriage is in the center of the span, both keepers are riding on the spears of the carriage. The coupling will not permit a keeper to pass, so that, as the carriage moves toward one tower and back to the center, one keeper rides with it and the other keeper remains in the center supporting the fall rope and haul ropes. When the carriage passes the center on the return trip, the keeper which was riding on it drops off at the coupling and the other keeper is picked up to ride with the carriage. One keeper is always at the center to support the fall rope and haul ropes. The fall block rides below the carriage at all times. It is a single sheave counter-weighted block with a hook on its lower en
block weighs 460 pounds but may
weighing over 120 pounds. The fall rope is
runs through sheaves on the carriage down t
back through sheaves on the carriage to a hoist

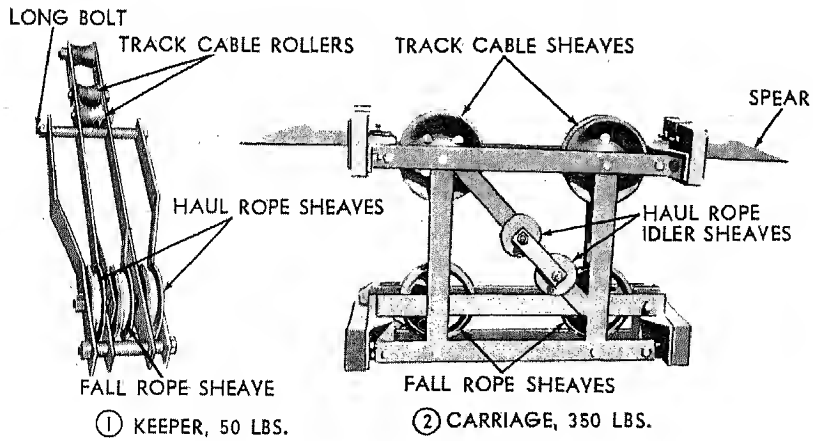


Figure 132. Cableway carriage and keeper.

tower. Once raised to a given height by taking up on the fall rope with the hoist unit, the fall block will remain the same distance below the carriage as the carriage moves back and forth between the towers until the fall rope is adjusted again by the hoist unit.

e. Power Unit. The power unit operates the continuous haul rope to move the carriage back and forth. A power unit has been developed for use with the M1 and M2 light aerial tramways and the medium cableway. It is an enclosed skid-mounted gasoline-engine-driven unit (fig. 102) delivering 20 hp at the spool at a crankshaft speed of 2,250 rpm (Continental Model SF–162) complete with an industrial clutch, muffler, radiator, and head. A double universal with slip propeller shaft drives a heavy duty industrial type transmission with a forward and reverse drive ratio of 40 to 1. A drive spool for the haul rope is located on the output shaft at the rear end of the unit. One end of the haul rope is fastened to a wedge socket on the carriage. The haul rope passes over a sheave on the keeper, over a sheave on the far tower, around a tail sheave there, back over a tower sheave, through both keepers to a sheave on the near tower, down to the power unit and around the drive spool, back up over a sheave at the top of the tower, and back through the near keeper to the carriage, where it is fastened to another wedge socket. The power unit is operated in forward or reverse drive to move the carriage in the desired direction. Detailed operation and maintenance instructions for this power unit are covered in a separate technical manual TM 5–9157.

f. Hoist Unit. The hoist unit is a gasoline-engine-powered drum hoist mounted on a steel toboggan (fig. 133). One end of the fall rope is anchored at the far tower. The fall rope passes through the far keeper to the carriage, down around the fall block, up through the carriage and near keeper, over a sheave at the near tower and down to the drum of the hoist unit, where it is fastened. When the hoist unit pays out cable, the fall block lowers. When the hoist unit takes up cable, the fall block and attached load are raised to the desired height below the carriage.

g. Rigging Accessories. Single blocks, double blocks, triple blocks, snatch blocks, wire rope cable grips, a hand winch, and short sections of wire rope are included in the erection equipment of the set for use in installing guylines, slings, anchors, takeups for the various cables, and leading blocks for the haul rope. Two 30-foot sectional prefabricated gin poles are included for use in erecting the towers. Each gin pole is in three 10-foot sections. The sections are fitted together with sleeves (fig. 134) and bolted securely.

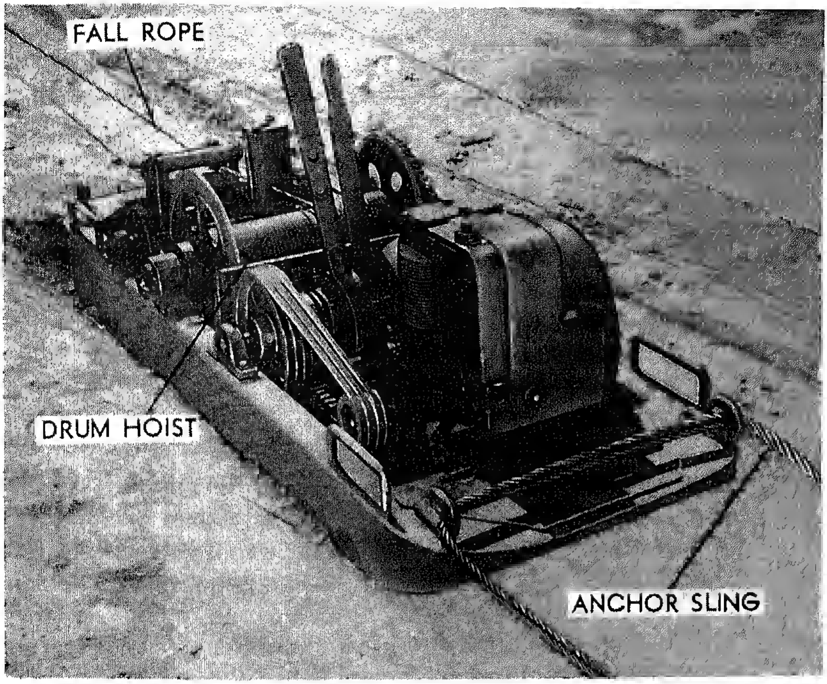


Figure 133. Toboggan mounted hoist unit.

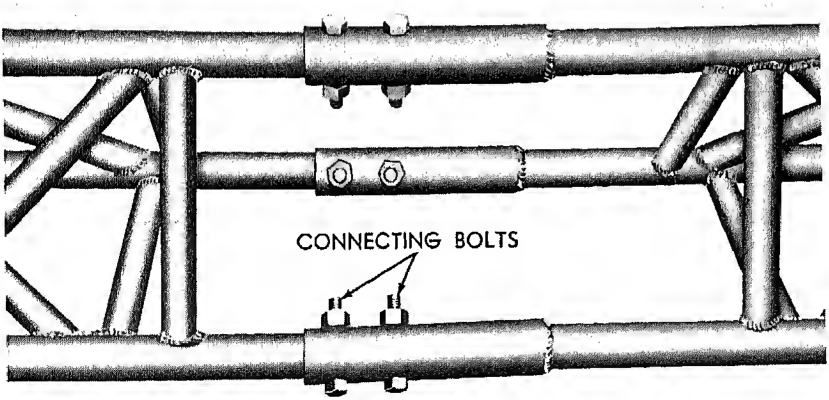


Figure 134. Connection of gin pole sections.

158. Transportation

Component parts of the medium cableway are so designed that the components and erection tools can be transported in four 2½-ton-6 x 6-cargo trucks.

Section II. ERECTION

159. Procedure

After a site is selected for installation of the medium cableway, the locations of towers and tower heights are determined. Anchorages are located and prepared for the tower guys and cables. The towers are then assembled and erected and the track cable, haul rope, and fall rope erected and rigged.

160. Site Requirements

Terminal sites must be accessible (para. 8) so that materials being transported over the cableway can be moved up to and hauled away from the terminals. There must be ample room at each site for locating guylines (fig. 130), power unit, anchorages, and for assembling towers and other components. A level circle roughly 100 feet in radius will usually be sufficient. If trees or rocks are readily available at the site, they can be used as anchorages and will simplify the erection procedure. When the terrain is very rugged, it may be necessary to select two or three possible sites for the installation. For each site considered, the length of span is determined by stadia or triangulation, and a survey of the planned cableway centerline is made. A profile (para. 9) of the terrain is drawn up and tower height determined (para. 164). From a consideration of this data, the most advantageous site is the site which combines the shortest towers, the shortest span length, and the most accessible tower locations.

161. Working Party

The working party for erection of the medium cableway should be divided into two groups, one to work at each terminal. A typical organization for each group is shown in table XIV and would include four main parties and two rigging parties. Tools required and typical duties are shown for each party. The most important problem is to assign duties and numbers of men to the various parties in such a manner that each group will complete its assigned tasks in an orderly manner and the various operations will take place in the correct sequence. If the crossing is difficult, a separate party may be required to transport materials to the far terminal so that the main parties at that terminal will not lag behind the comparative party at the near terminal.

Table XIV. Typical Organization of Working Parties at Each Terminal

Party	Number		Equipment	Duties
	NCO's	EM		
Layout	1	4	1 metallic tape, transit, stadia rod.	Lay out tower site, mark anchorages, clear site, cut and install deadmen, aid in final rigging.
Deadman	1	8	Mattock, shovels, saws, RR picks.	Unload material, transport material (farshore party), cut and install deadmen, aid in final rigging.
Tower	1	8	Wrenches; level; ball-peen hammer; double-face striking hammer.	Unload material, transport material (farshore party), assemble tower, raise tower, aid in final rigging.
Holdfast	------	2	Double-face striking hammers.	Unload material, transport material (farshore party), install holdfast, aid in raising tower, aid in final rigging.
Rigging (2 parties of 2 each).	------	4	Wrenches; ball-peen hammer.	Unload material, transport material (farshore party), preliminary rigging, aid in raising tower, final rigging.
Each group	3	26	----------------	----------------
Both groups	6	52	----------------	----------------

162. Erection Tools

Tools and equipment required for the erection of the medium cableway are included in the set. They are listed in table XV.

163. Terminal Layout

Site requirements are discussed in paragraph 160. At each terminal of the final site, stake out the tower location and track cable and tower guyline anchorages (fig. 130). The two back guy anchorages must be the same distance from the tower and at the same angle from the line of the track cable to keep the stress in the two guys equal and prevent tipping of the tower under load. The vertical angle of a tower guyline with the ground is controlled by the distance of its anchorage from the base of the tower. As this vertical angle increases, the stress in the guyline increases. It should never be more than 45°, meaning that the distance of the anchorage from the base of the tower should always be greater than the height of the tower. At the near side terminal, the positions for the power unit and hoist unit are staked out after the anchorages are staked out.

Table XV. Tools Required for Erection of Medium Cableway

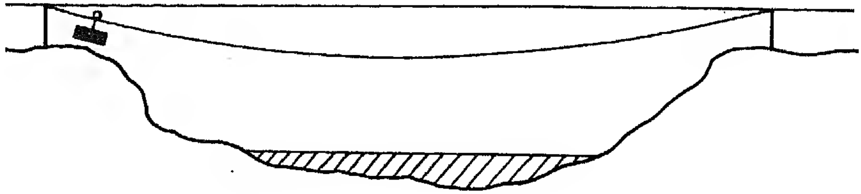
Item	Quantity
Ax, single bit	8
Bar, wrecking	4
Battery, dry	18
Belt, safety, industrial	2
Block, tackle:	
2-ton, ½-in. dia, half-round pattern	4
2-ton, ½-in. dia, oval pattern	2
2½-ton, ½-in. dia, diamond pattern	2
2½-ton, ¾-in. dia, plain	16
Cable, telephone	1
Chest, tool	4
Climber's set, tree and pole	2
Clip, wire rope, ⅜-in. dia	120
Crowbar	6
Cutter, wire rope, hand operated	2
Driftpin	8
File, hand	6
Fire pot, liquid fuel	1
Gin pole section, bottom	2
Gin pole section, middle	2
Gin pole section, top	2
Grease gun, hand	1
Grip, cable, jaw:	
Parallel	8
Wedge and roller	2
Hammer, hand:	
Carpenter's	2
Machinists' ball-peen	4
Striking, drilling	12
Handle, socket wrench	16
Hoist, chain	2
Hydrochloric Acid, technical	1
Insulation tape, electrical	6
Jack, reel, hand	4
Ladle, melting, hand	1
Level and plumb	2
Marlinspike	4
Mattock	8
Nippers, end cutting	6
Nut, self-locking, hexagon	72
Peavy	8
Pick, digging	8
Picket, steel	50
Pipe, steel	3
Pliers	6
Rope, manila	4,600 ft
Safety can, fuel	5
Saw, crosscut, two-man	2
Screw, cap, hexagon head	60
Shackle, anchor	2

Table XV. Tools Required for Erection of Medium Cableway—Continued

Item	Quantity
Shovel, hand:	
D-handle	10
Round point	10
Strap, safety, industrial	2
Tape, measuring	4
Telephone set, field type	3
Thimble, rope	2
Wire, steel, carbon:	
5-lb coil, .0475-in. dia	2
12-lb coil, .0800-in. dia	1
Wire rope, steel:	
⅜-in. dia, 40-ft unit length	14
⅜-in. dia, 300-ft unit length	2
Wrench, coupling, medium cableway	4
Wrench, open end, adjustable:	
0- to 15/16-in. jaw opening; 8-in	4
0- to 1.322-in. jaw opening; 12-in	6
Wrench, open end, fixed	16
Wrench, pipe	2
Zinc slab	25 lb

164. Determination of Tower Height

The towers must be high enough so that the moving load will clear all obstructions. The strength of the towers is increased as their height is decreased. Short towers also reduce the distance through which the load must be raised and lowered with the fall block at the terminals, reducing the operating time per trip. Therefore, the towers should be as short as possible while still providing clearance. Where the terrain between towers is at a lower level than the base of the towers (①, fig. 135), clearance of the load as the carriage approaches the terminals determines tower height. Where high points of ground exist between the towers (②, fig. 135), clearance at the high points determines tower height. In order to determine correct tower height, draw up a rough profile of the terrain between towers (AB, fig. 136) to scale on graph paper. Obtain the loaded deflection for the span from table XVI and plot a dotted line curve of this deflection on the graph paper (CD, fig. 136). This curve must clear all points by a sufficient amount to be safe (3 to 5 ft.). If it does not, the entire curve is raised on the graph until clearance is satisfactory. The depth of the carriage and fall block will be a minimum of 5½ feet. The depth of load plus slings is variable and must be estimated. These two are added together and a second deflection curve (EF, fig. 136) is plotted on the graph this number of feet above the first curve as a solid line. This solid line



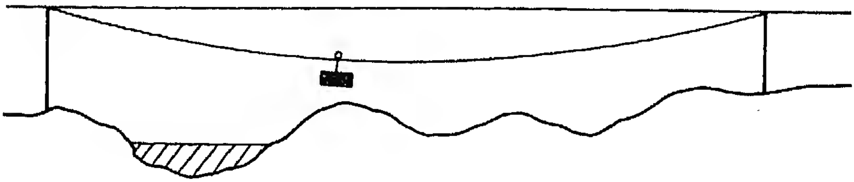


Figure 135. Terrain variations in determining tower height.

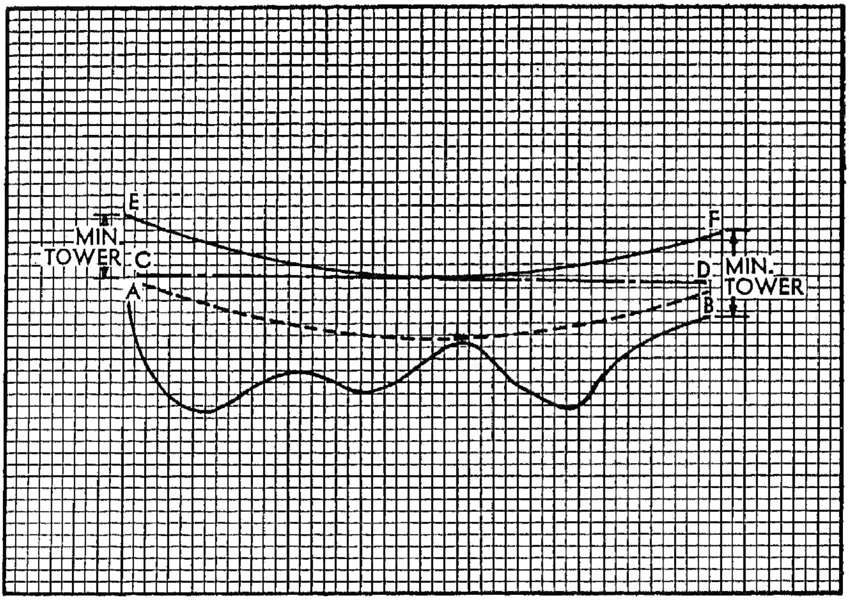


Figure 136. Use of profile or graph paper to determine tower height.

determines minimum tower height. Since the towers are sectional, that number of sections is used which will obtain the next highest tower. As an example, assume that minimum height for the near tower is shown by the graph to be 40 feet. Three intermediate tower sections would produce a tower height of 36 feet. Therefore four intermediate sections are used, producing the next higher tower.

Table XVI. Loaded Deflection, Medium Cableway

Span in feet	Erection sag (ft.)	3,000-pound load deflection (ft.)
1,200	18	52
1,000	12	42
800	8	33
600	4½	23
400	2	15

165. Preparing Anchorages

Natural anchorages such as trees, stumps, or rocks may be used wherever available. If necessary, deadman anchorages can be placed; refer to paragraphs 34 through 39 for detailed methods of placing anchorages. Anchorages for back tower guylines should be able to withstand a pull of 8,000 pounds and those for front tower guylines a pull of 1,000 pounds. The anchorage for the track cable must be able to withstand a pull of 28,000 pounds plus 11,000 pounds of pull from the haul rope and fall rope. Slings around the anchorage for the track cable at each terminal must be ⅞-inch diameter wire rope. Slings for the other anchorages must be ½-inch diameter wire rope.

166. Location of Power Unit and Hoist Unit

The location for the power unit and hoist unit is chosen to suit ground conditions. The hoist unit must be ahead (fig. 130) of the power unit by about 10 feet and to one side to prevent fouling of the lines to the two units. Line pull for the hoist unit is from 2,000 to 3,000 pounds. Line pull
pounds. Each unit mus
Stakes driven against the t
as a tree, holdfast, or deadm

167. Assembly of Towers

The tower base plate must be placed absolutely level on firm ground. Level the area and set the tower base plate in position. If the soil under the base plate is not firm gravelly soil or hard clay, place some of the wood cribbing from the set beneath the base plate to distribute the tower weight over a greater area. Using a carpenter's level (fig. 137), check the tower base plate very carefully to be certain it is absolutely level. Then drive anchor stakes (fig. 138) against the

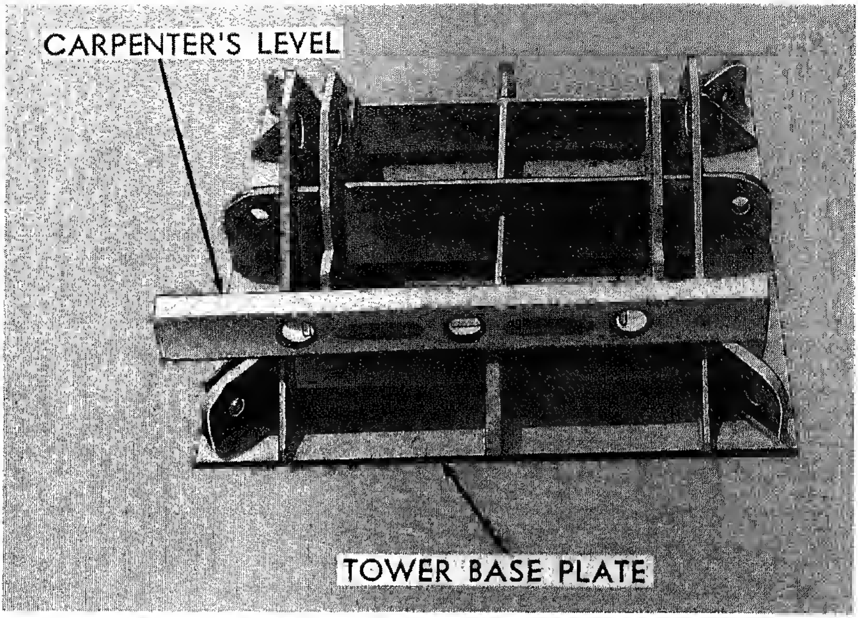


Figure 137. Leveling tower base plate in position.

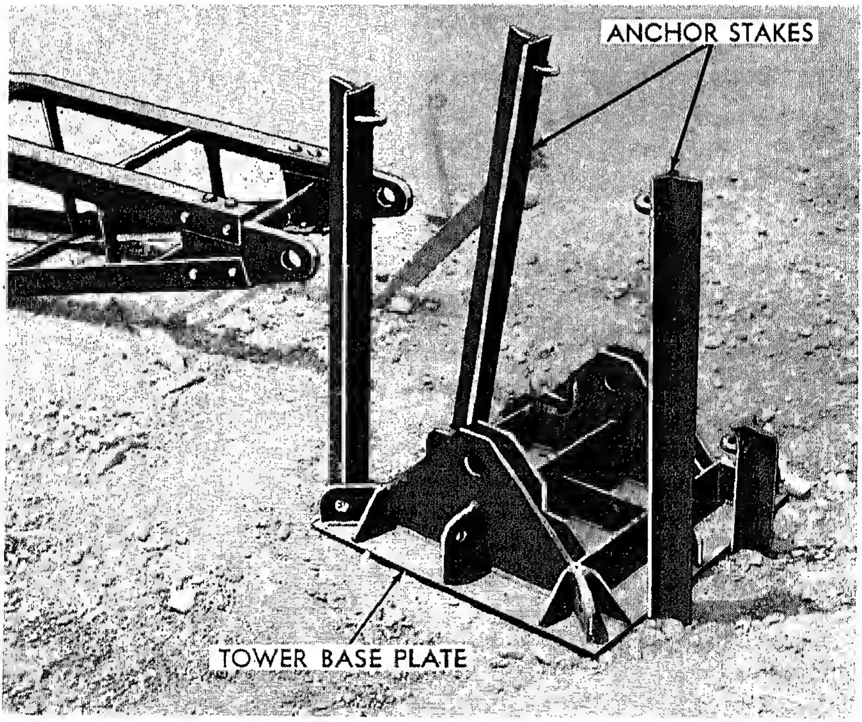


Figure 138. Driving anchor stakes at tower base plate.

base plate to hold it in position. The tower is now assembled on the ground along the line of the cableway on the side of the base plate away from the gap to be spanned. Place the tapered end of the pivoted tower section on the tower base plate (fig. 139) and insert the tower base plate pin through both sides of the pivoted tower section and tower base plate. Lower the upper end of the pivoted tower section about the base plate pin until it is horizontal. Place one end of an intermediate tower section against the end of the pivoted tower section (fig. 140) and place splice angles at each corner. Line the holes in the splice angles up with the holes in the pivoted tower section and insert 16 bolts, 4 at each corner. Install washers and nuts but do not tighten. Line the holes in the splice angles up with the holes in the intermediate tower section, using drift pins if necessary, and insert 16 bolts in these holes. Install washers and nuts and tighten the nuts on all bolts securely. Additional intermediate tower sections are added in the same manner until the desired tower height (para. 164) is reached. Bolt the top tower section in place (fig. 141) in the same manner to complete the tower. Attach the upper blocks for the two back tower guys to links on the top tower section and attach the lower blocks to their anchorages. Fasten one end of each ½-inch wire rope back tower guy to the becket of its lower block and reeve

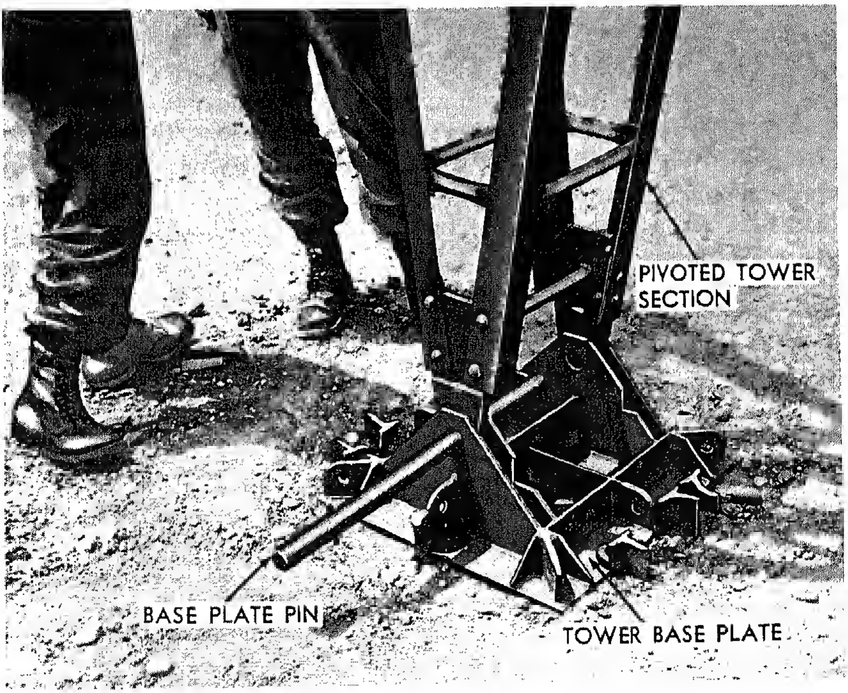


Figure 139. Pinning pivoted tower section to tower base plate.

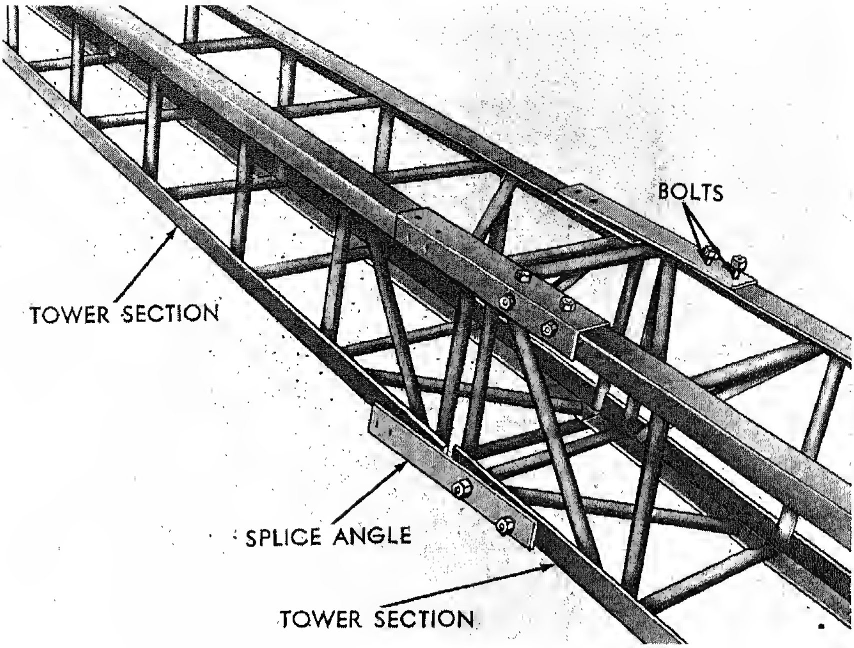


Figure 140. Connecting tower sections with splice angles.

it through its upper block and back through its lower block. Take up on each guy until most of the slack is out of the line. Attach one end of each of the two front tower guys to a link on the top tower section. A thimble should be used in the wire where it passes through the clips. Wedge sockets can be used for these connections if they are available. Lash a single block to the upper side of the tower (fig. 142) about three-fifths of the tower height from the base for use in the raising tackle.

168. Erection of Gin Pole

Two prefabricated gin poles are included in the set for use in erecting the towers, one for each tower. Each gin pole has a top, middle, and bottom section. Assemble the gin pole on the ground by bolting the sections together (fig. 134). Dig a shallow hole in the ground 15 to 20 feet from the tower base on a line between the two towers as an anchorage for the base of the gin pole. Set the base at this point with the gin pole lying on the ground on a line between towers pointing away from the tower to be raised. Place a temporary anchor line from the base of the gin pole to a holdfast to prevent motion of the base during erection. Attach a snatch block to the top of the gin pole. Attach the end of a ⅜-inch diameter wire rope to the becket of the block on the tower (fig. 142) and reeve it through the snatch

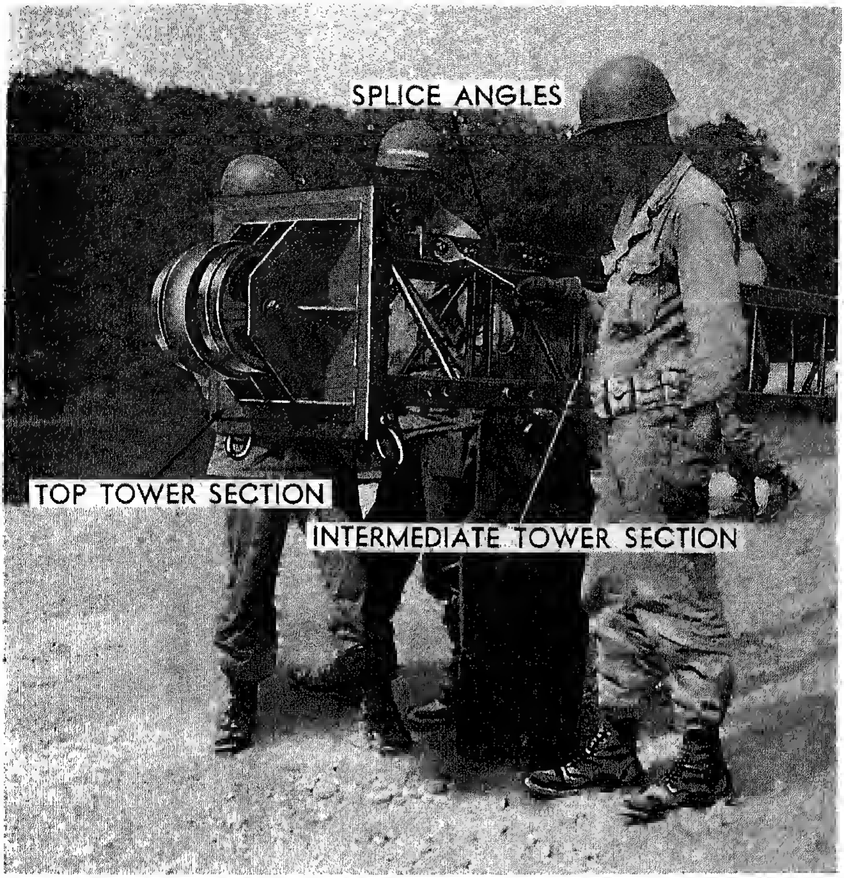


Figure 141. Bolting top tower section in place.

block at the top of the gin pole and back through the block on the tower to the base of the tower. Bolt the hand winch supplied in the set to the base of the tower and secure the end of the line to the hand winch. Attach two front guys and two back guys to the top of the gin pole. Each front guy is a single ⅝-inch diameter fiber rope. Each back guy is made up of a 40-foot length of ⅜-inch diameter wire rope and a tackle using two double blocks and 200 feet of ⅝-inch diameter fiber rope. Fasten the lower ends of the back guys to their anchorages and take the slack out of the tackle. While several men lift on the top end of the gin pole to raise it off the ground, take in line with the hand winch until the angle of gin pole will permit the hand winch alone to raise it. Continue taking in line on the hand winch until the gin pole is in a vertical position. While the gin pole is being raised, men stationed at the front guys steady it and the men on the back guys pay out line slowly to maintain a slight steady tension. When the gin pole is vertical, secure all guys to anchorages.

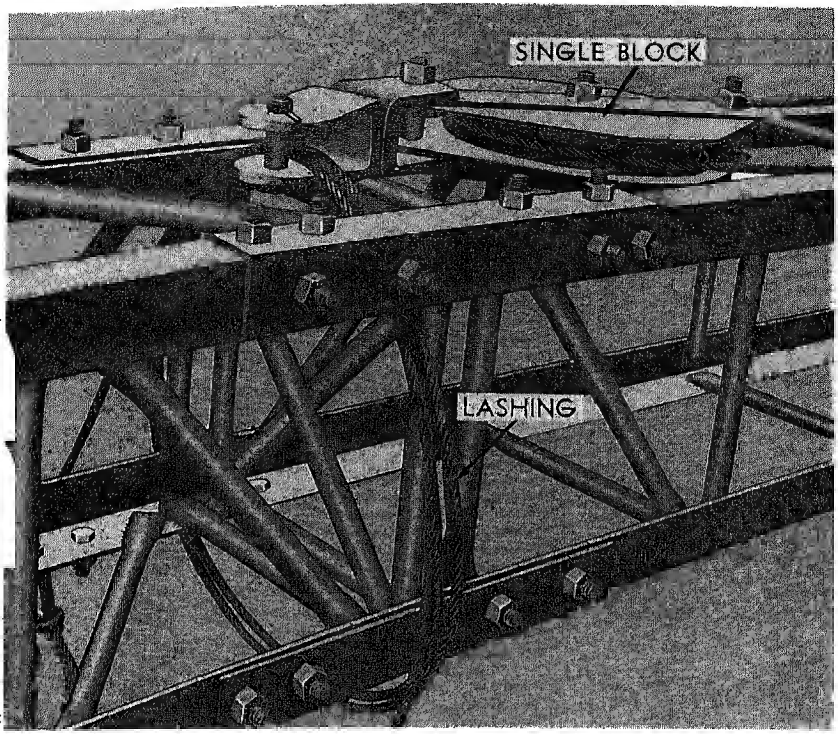


Figure 142. Block lashed to tower for raising tackle.

If for any reason the prefabricated gin pole is not available, a substitute must be used. Trees may be used, if available at the site. A timber gin pole or timber shears may be erected (TM 5-725). In any case the tackle for raising the tower must be attached 25 or 30 feet higher than the base of the tower to provide a satisfactory lifting angle for erection of the tower.

169. Erection of Tower

Disconnect the raising tackle used to erect the gin pole and unbolt the hand winch from the base of the tower. Anchor the hand winch at the base of the gin pole. Attach the end of a ⅜-inch diameter wire rope to the becket of the snatch block at the top of the gin pole and reeve the wire rope through the block on the side of the tower (fig. 142), through the snatch block at the top of the gin pole, and down to a leading block at the base of the gin pole before connecting it to the hand winch. Attach temporary fiber rope back guys to the tower for use as steadying lines. Men are stationed at each back guy and front guy to steady the tower during erection. When power is applied to the winch, the tower will be raised. When the tower is in a vertical position, attach the two front guys to their anchorages with

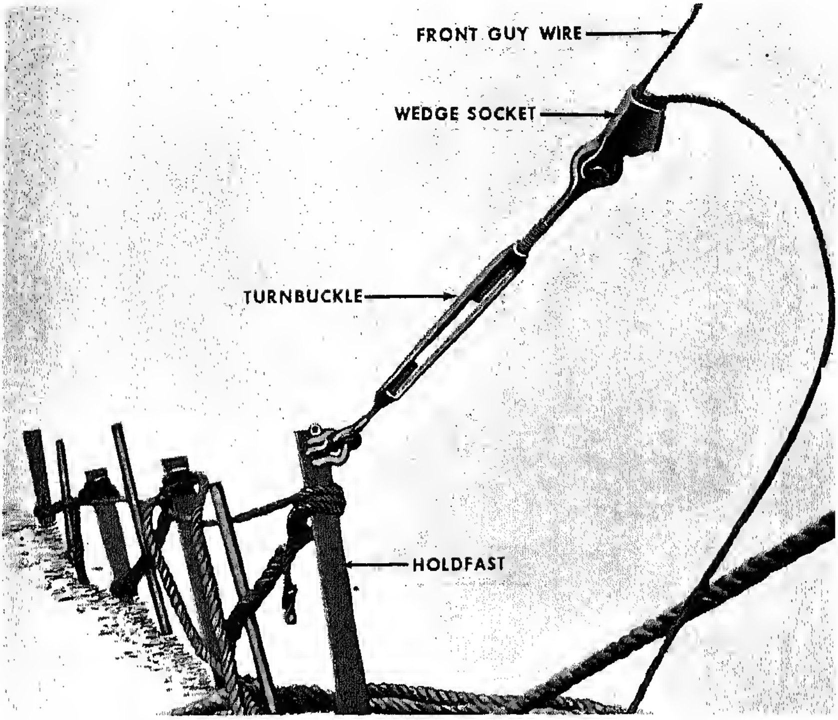


Figure 143. Rigging for front tower guy.

wedge sockets and turnbuckles as shown in figure 143. Take up the slack in the permanent back tower guy tackles. Place a cable grip on the lead line and another cable grip on the line fastened to the becket of the lower block in each back tower guy tackle. Insert the lever operated chain hoist between these cable grips and take up on it to obtain sufficient tension to stabilize the tower. Fasten the two lines together with wire rope clips (fig. 144) and remove the lever operated chain hoist and cable grips. Remove the temporary fiber rope back guys. Lower the gin pole and move it to clear the area for operation of the cableway. Tower erection with the prefabricated gin pole is shown in figure 145. The hand winch or a power winch can be used for power.

170. Unreeling Haul Rope

The haul rope is installed before the other ropes so that it can be used with power to move the other components. It is a ⅜-inch diameter wire rope 3,000 feet long doubled and wound on the reel with the bight on the inside. Securely fasten the ends of the rope at the near tower and haul the reel to the far tower, with the haul rope paying out as the reel is moved. The full reel weighs approximately 750 pounds.

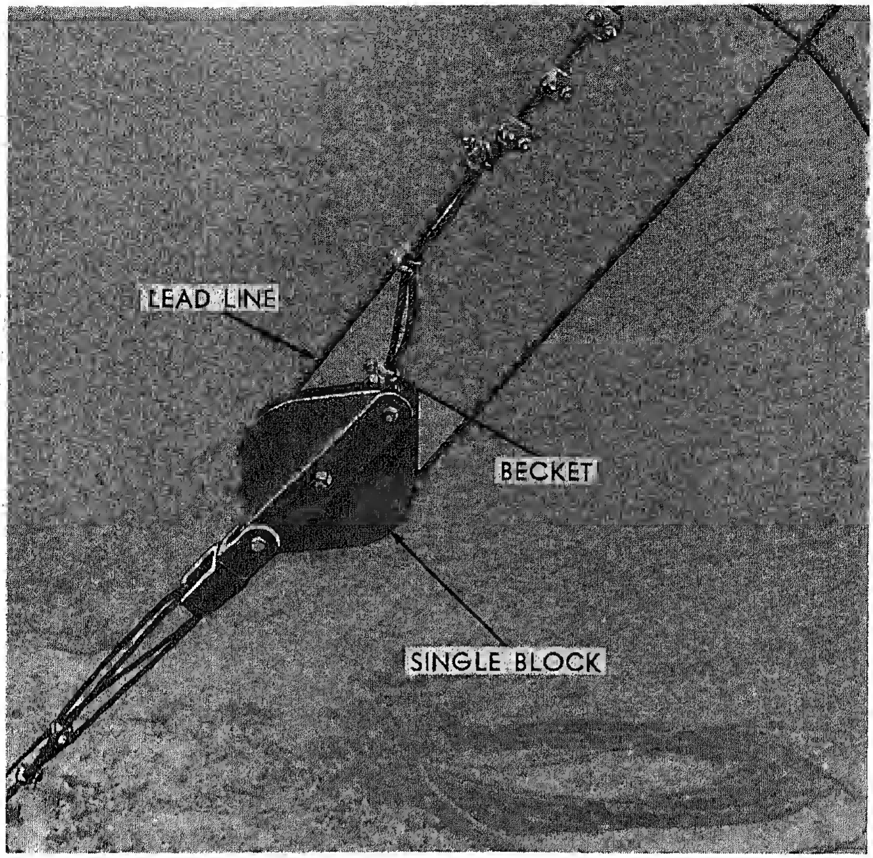


Figure 144. Rigging for back tower guy.

When the entire cableway crossing is over rocky terrain or marshy ground, the reel must be moved by hand. When the crossing is over a river, or a portion of it is over a river, the reel must be moved across the river by boat. If possible, mount the reel in the boat on uprights so it can turn, permitting the haul rope to pay out over the stern as the boat crosses. Some provision for braking or slowing the motion of the reel is required when this method is used. Otherwise, the reel will gain impetus as the amount of rope uncoiled increases, and the whole reel will uncoil without stopping. If the reel cannot be mounted in the boat so that it will turn, a different system must be used. The ends of the rope are not fastened at the tower. All the rope is uncoiled from the reel at the near bank of the stream. Starting at one end, enough rope is coiled in the bottom of the boat to reach across the stream. The boat is moved across the stream, paying out the haul rope from the coil in the boat. At the other side, the end of the rope is passed through a snatch block fastened temporarily on the shore. Enough

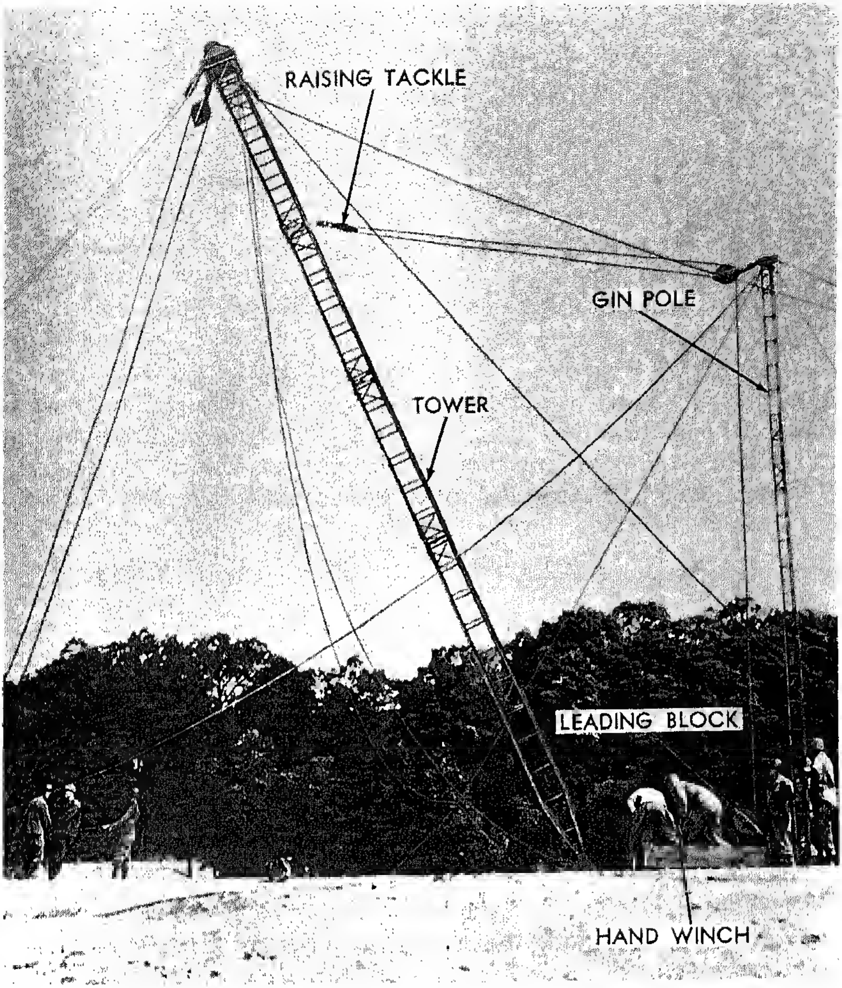


Figure 145. Erecting tower with prefabricated gin pole.

rope is pulled through the snatch block and coiled in the bottom of the boat to reach across the stream, and the boat returns to the near side paying out the rope coiled in the bottom. The end is now dragged to the near tower and fastened. This method is much more cumbersome then the first method and less satisfactory.

171. Installation of Haul Rope

The haul rope is unreeled as outlined in paragraph 170 above. At the far tower, hoist both parts of the haul rope to the top of the tower. Place one part over each outside sheave at the top of the tower, with the bight hanging down on the back side. Insert a snatch block in the bight as a tail block. Fasten a line from the tail block to a hand winch,

so that the hand winch controls the tension in the haul rope. At the near tower, unfasten one end of the haul rope and hoist it to the top of the tower where it is passed over one outside sheave. The two parts of the haul rope must not cross each other between towers. To avoid this use the sheave on the same side of the near tower as the sheave on the far tower over which this same part of rope passes. Pull the end of the haul rope to the base of the tower and pass it through one sheave of a double block, which will serve as a leading block. Lead the haul rope to the power unit and wind 2½ turns around the drive spool before passing the end back through the other sheave of the leading block. Haul the end to the top of the tower and place it over the remaining outside sheave. Tie a line on the free end temporarily to keep it from slipping. Unfasten the other end of the haul rope and pull these two ends together. Place four wire rope clips on the two ends to make the haul rope continuous. Take up on the hand winch at the far tower to pull on the tail block and tighten the haul rope ready for use.

172. Installation of Track Cable

a. Unreeling. Support both track cable reels on jacks for ease in unreeling them. If a stream or ravine is being crossed, set up both reels on the near side in the line the cableway will traverse. Release tension on the haul rope with the tail block and hand winch until the haul rope is accessible to men working at the reels. Unreel some of the track cable from the reel which has the wire rope coupling piece on the inside of the reel. At a point about 70 feet from the end of this, tie it securely to one piece of the haul rope with a short piece of fiber rope. Tie a short section of pipe or log near this point to prevent the haul rope and track cable from twisting about each other.

b. Pulling Across Gap. Operate the power unit slowly to pull the haul rope across the gap, pulling the track cable across with it. Stop the power unit when all but about 50 feet of track cable has unreeled and attach a snubbing line to it to control the end of the track cable when it clears the reel The snubbing line is a piece of fiber rope, one end of which can be tied to a tree or held by several men to take the strain off the track cable. Unreel the remaining track cable on this reel by hand and couple the end to the coupling piece on the second reel with the coupling plug. Insert the two coupling pins (para. 157*c*) and peen their ends to complete the coupling. Unfasten the snubbing line and start the haul rope moving with the power unit again. When all but about 100 feet of track has been unreeled, stop the haul rope and fasten the snubbing line to the track cable. Unreel the rest by hand.

c. Rigging. When the log or pipe fastened to the track cable reaches the far shore, or approaches the tower, untie the rope which fastens it in place and continue pulling the track cable with the haul

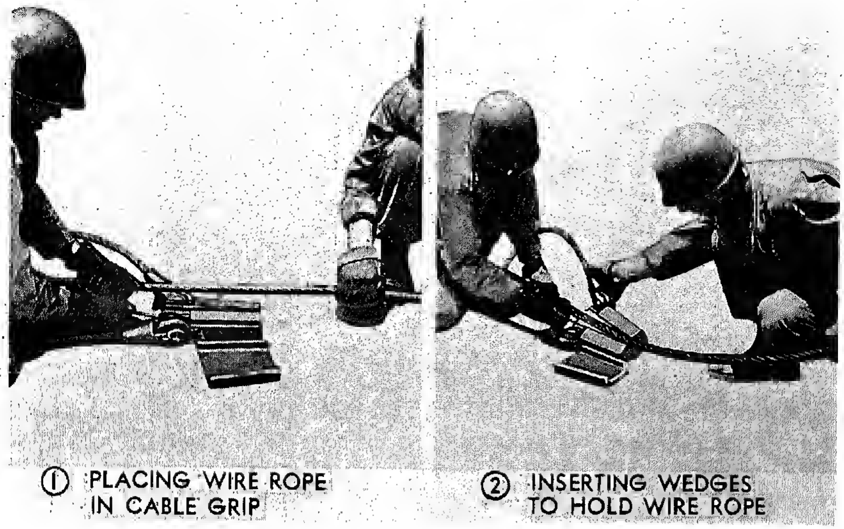


Figure 146. Placing wedge-type cable grip.

rope until the track cable passes over the top of the tower and down as far as the haul rope can pull it. Place the track cable in its sheave on top of the tower. Place the end of the track cabl cable grip (fig. 146) and fasten it to its anchorage (fig. the rope which fastens the track cable to the haul rope to complete the installation at the far tower. At the near tower, pass the end of the track cable through the carriage under the two upper sheaves (fig. 148) and through one keeper between the two track cable rollers (fig. 132). Hold the track cable with the snubbing line and attach a temporary tag line of fiber rope from the carriage to the top of the tower (fig. 148). Reeve the fall rope through the fall rope lead block over the idler sheave at the top of the tower and attach it to the track cable about 60 feet from the end of the track cable. Haul on the fall rope, releasing the track cable snubbing line, to pull the track cable to the top of the tower.

d. Near Tower. Place the track cable in the track cable sheave on top of the tower and pull the end by hand toward the anchorage. Fasten onc triple block of the track cable tackle to the track cable with a wedge-type cable grip. Attach the other block to the sling of the anchorage. Put the lead line of the tackle on a hand winch and take a strain on the winch. Unfasten the fall rope and other ropes from the track cable but leave the tag line on the carriage. Pull the track cable to the required tension with the hand winch. The tension is determined by obtaining the erection sag from table XVI. A target is then attached to each tower at a distance below the top equal to the erection sag. Take up on the hand winch to

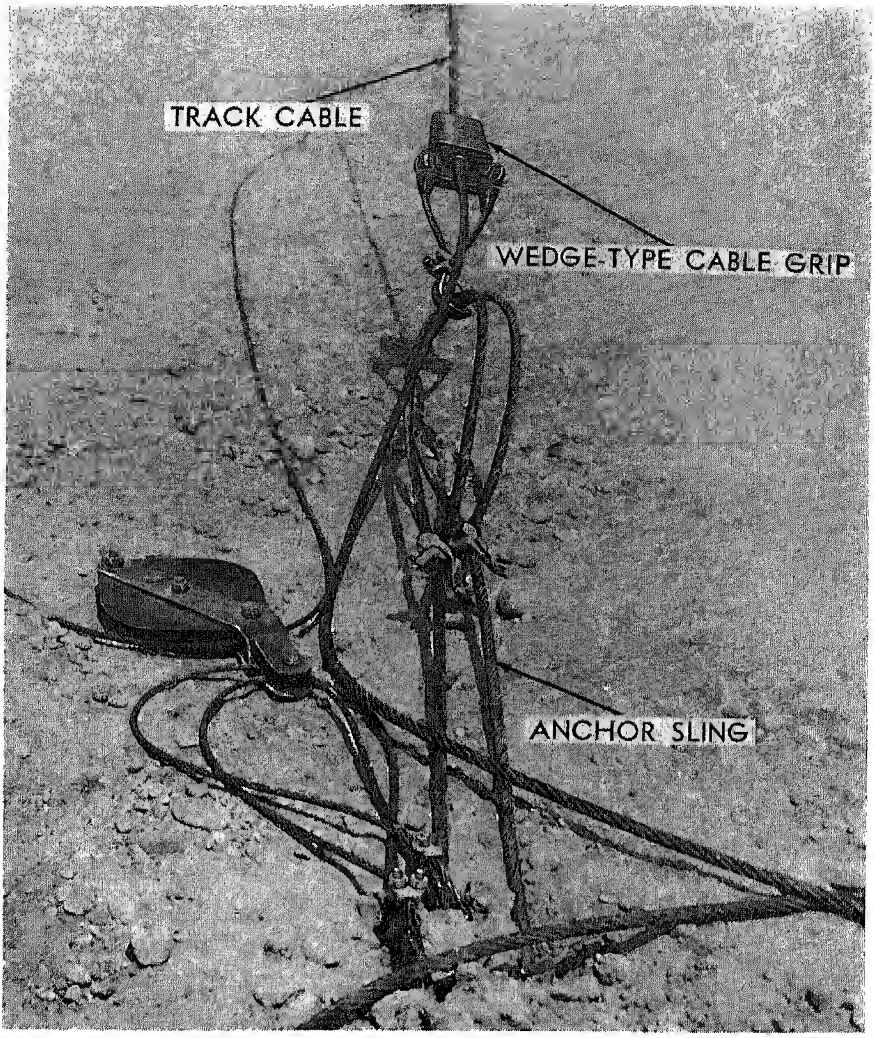


Figure 147. Track cable anchorage for tower.

tighten the track cable until the lowest point on the track cable coincides with the line of sight between the targets on the two towers. Fasten the lead line of the track cable tackle to the preceding part with four wire rope clips when the correct sag is reached.

173. Rigging Fall Rope and Haul Rope

a. Haul Rope. Using the tag line, pull the carriage to the tower and tie it there temporarily. Operate the power unit to move the clipped connection of the haul rope to a position beside the carriage. Fasten each end of the haul rope to the track cable temporarily to

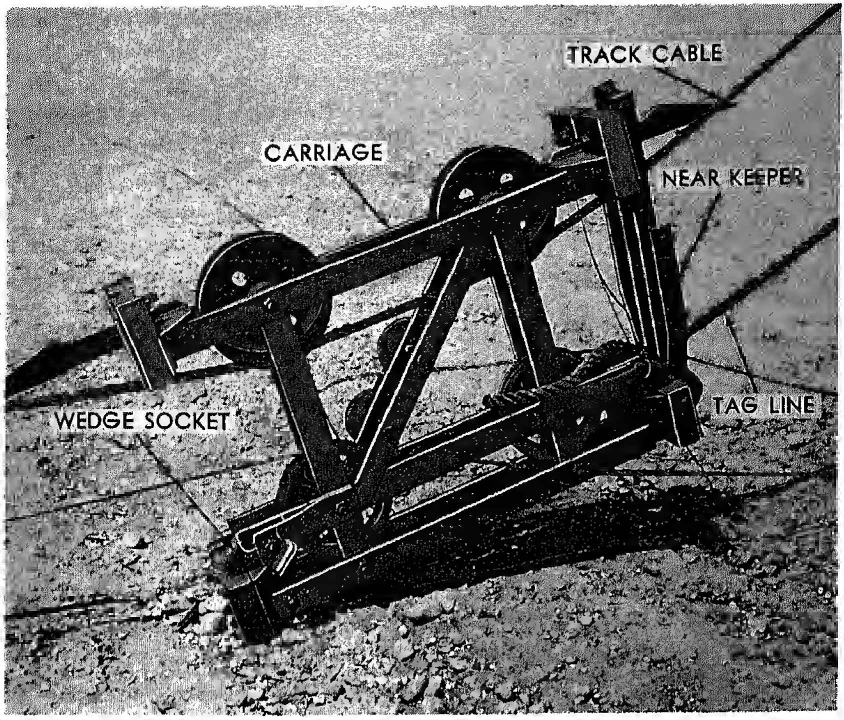


Figure 148. Carriage and rear keeper before tightening cable.

hold the strain on the line while working with it. Remove the wire rope clips fastening the ends of the haul rope together. Attach the far end of the haul rope to the wedge socket on the far side of the carriage. Remove as much slack as possible and fasten the near end of the haul rope to the wedge socket on the near side of the carriage. Remove the temporary fastenings holding the ends of the haul rope to the track cable. Place the continuous, or return side of the haul rope between the haul rope idler sheaves on the carriage. Unscrew and remove the long bolt near the top of the keeper and place the two parts of the haul rope in the two outer guides of the keeper so each part will run over one of the outside sheaves. Replace the long bolt and install and tighten the nut on it to hold the keeper securely.

b. Fall Rope. Place the fall rope over the remaining idler sheave at the top of the tower, over the center sheave of the keeper, and tie the end of it to the carriage temporarily. Untie the temporary tag line holding the carriage to the tower. Operate the power unit to pull the carriage to the far tower, hauling the fall rope across. Untie the fall rope from the carriage and place it over the fall rope sheave on the carriage nearest the near tower and down to the ground. On the ground, reeve the fall rope through the fall block and hoist the end of

it back up to the carriage and over the remaining fall rope sheave on the carriage. Pass the end of the fall rope through the center guide of the farside keeper, which had not previously been installed. Place the end of the fall rope over the unused idler sheave at the top of the tower, pull it down to the main track cable anchorage, and anchor it.

c. Farside Keeper. The farside keeper now has the fall rope through the center guide, but otherwise is not in place. Partially disassemble the keeper by removing bolts until it can be reassembled over the track cable. Unscrew and remove the long bolt near the top and place each part of the haul rope through one of the outer guides. Replace all bolts and nuts and tighten them to hold the keeper securely in place.

174. Alternate Method of Erecting Cables

a. Moving Ropes. The cables can be erected by an alternate method if necessary to permit rigging at both towers by the same rigging party. Unreel the haul rope as outlined in paragraph 170 but do not install it. Place it in a snatch block on the far side, wind 2½ turns around the drive spool of the power unit on the near side and fasten the ends together with wire rope clips. The haul rope can now be used for pulling the other components across but is not connected to the towers. Tie the track cable end to the haul rope and drag it across as discussed in paragraph 172 until the wire rope coupling is approximately in the center of the span. Fasten a snubbing line to each end of the track cable to hold it temporarily and untie it from the haul rope. Tie the end of the fall rope to the haul rope and pull it across the gap. Snub the ends of the fall rope temporarily and untie the end from the haul rope. All ropes are now across the gap, but are not in place on the towers nor through the carriage.

b. Far Tower. Remove the temporary snatch block from the haul rope at the far tower and rig the permanent tail block, leaving plenty of slack in its takeup line. Run a fiber rope over the track cable sheave at the top of the far tower, hoist the two parts of the haul rope up, and place them in the two outside sheaves at the top of the tower. Put the end of the track cable between the track cable rollers on the far side keeper and tie the fiber rope to the track cable. Put a light tag line on the keeper to control it temporarily. Haul the end of the track cable over its sheave at the top of the tower and down to its anchorage. Fasten it in place. Put the fiber rope over the idler sheave and hoist the fall rope to the top of the tower. Snub it temporarily, untie the fiber rope, pass the end of the fall rope through the center guide of the keeper, and tie the fiber rope back to the end of the fall rope. Unfasten the snubbing line and haul the fall rope down to its anchorage.

Unscrew and remove the long bolt from the keeper and insert each of the two parts of the haul rope in one of the outside guides of the keeper. Reassemble the bolt through the keeper and tighten it. Untie the tag line from the keeper. The far tower is not rigged.

c. Near Tower. Pass the end of the track cable through the carriage and near side keeper. Fasten a temporary tag line from the carriage to the top of the tower. Place a fiber rope over the track cable sheave at the top of the tower and tie one end to the end of the track cable. Haul the track cable over the top of the tower and down to its takeup tackle and anchorage, which are fastened to it and taken up as outlined in paragraph 172. Pull the carriage and keeper to the tower and fasten them there temporarily with the tag line. Place the fiber rope over the idler sheave at the top of the tower and hoist the fall rope to the top of the tower. Reeve the end of the fall rope over the fall rope sheave of the carriage on the side toward the far tower, down to the ground, and through the fall block. Hoist the end back up and pass it over the remaining fall rope sheave on the carriage and through the center guide of the keeper. Tie the end of the fiber rope to it and pull it over the idler sheave at the top of the tower and down to the hoist unit. Fasten snubbing lines to the ends of the haul rope and unfasten the wire rope clips holding the ends together. Remove the haul rope from the drive spool of the power unit. Hoist one end to the top of the tower, reeve it between the haul rope idler sheaves on the carriage and through one outer guide of the keeper. Tie the end of the fiber rope to it and pull it over one outer sheave on top of the tower and down to the leading block. Reeve the end of the haul rope through one sheave of this double block, take 2½ turns around the drive spool of the power unit and reeve the end back through the other sheave of the leading block. Hoist this end to the top of the tower, pass it over the remaining outer sheave and through the remaining outer guide of the keeper. Attach it to the wedge socket on the near side of the carriage. Hoist the other end of the haul rope to the top of the tower, remove as much as possible, and attach it to the wedge socket on the far side of the carriage. Remove all tag lines and snubbing lines to complete the rigging.

175. Adjustment

Check the sag in the track cable and adjust it if necessary (para. 172). Adjust the haul rope by taking up on the hand winch at the far tower to pull the tail block down. Operate the hoist unit to haul on the fall rope until the fall block is close to the carriage. Move the carriage back and forth several times by operating the power unit. Return the carriage to the near terminal and check tension of all lines and smoothness of operation. Adjust as necessary.

Section III. OPERATION

176. Normal Operation

a. Operating Crew. After the medium cableway is erected, a 12-man operating crew is required. One man operates the power unit and another operates the hoist unit. A 5-man crew is stationed at each terminal to load and unload the carriage. When loads must be made up in slings, a larger loading and unloading crew is required.

b. Operating Sequence. The power unit operator operates the power unit to pull the carriage to the loading position. The hoist unit operator slacks off on the fall rope, lowering the fall block until it can be hooked to the load by the loading crew. He then takes up on the fall rope to hoist the load up to the carriage. The power unit operator then operates the power unit to pull the carriage across the gap to the unloading position, at which time the hoist unit operator slacks off on the fall rope to lower the load until the unloading crew can unhook the fall block from the load.

c. Slings. When slings are required three should be made up. A load is made up in one sling and sent to the far shore. The carriage is returned empty. During the trip of the carriage, the loading crew loads a second sling which is hooked on and moved to the far shore while the third sling is being loaded. The unloading crew has now unloaded the first sling. After unhooking the second loaded sling from the fall block, the unloading crew hooks on the empty sling and [illegible] ready for loading.

177. Night Operation

Night and blackout operation reduce the speed with which men can load and unload the carriage but not the speed and operation of the cableway. However, the power unit and hoist unit operators cannot see the position of the fall block and carriage throughout their movement. To compensate for this, telephone communication is necessary. Field telephones provided in the set are used. One telephone at the loading position, one at the unloading position, and one shared by the hoist and power unit operators are usually adequate.

178. Operating Power Unit

The power unit supplied for the medium cableway and the M1 and M2 tramways is identical. Refer to paragraph 121 for general operating instructions on this power unit. Detailed operation and maintenance instructions for the power unit are covered in TM 5-9157.

Section IV. MAINTENANCE

179. Care in Handling

The tower parts, carriage, keepers, and prefabricated gin poles must be handled with care to avoid bending or deforming any of the parts. Bent or deformed parts must be removed and straightened at the earliest practicable time to prevent increased damage and unsatisfactory operation. All components should be inspected at frequent intervals so that damage can be prevented. Inspect rigging frequently and tighten loosened wire rope clips. Inspect wire rope, particularly anchorage slings, carefully for worn or broken wires. Replace any wire rope which shows signs of cutting. Refer to TM 5–725 for detailed instructions on the care of rigging.

180. Painting

The steel portion of the medium cableway, including the towers, carriage, keepers, sheaves, and blocks, is originally protected by paint. When inspection reveals chipping, scaling, or distintegration of the paint which exposes the steel, the surface should be carefully cleaned and painted. Scrub the exposed area with a wire brush to remove all rust. If the paint is flaking off, chip off the old paint around the exposed area before wire brushing. Wash the surface with cleaning solvent to remove all foreign material and let it dry thoroughly. Apply a rustpreventive priming coat, such as red lead or zinc chromate, and after this is dry apply the final coat of paint. Moisture and changing weather conditions cause deterioration of paint on metals. Keep parts in storage under cover to protect them from such conditions.

181. Lubrication

All idler sheaves, carriage sheaves, lead and tail blocks, fall blocks, and keeper sheaves must be lubricated at frequent intervals to maintain satisfactory service. These are heavy duty units. When a standard issue block is substituted for one of these it is necessary to install a grease fitting and grease it very frequently, as much as once per trip in some cases, to prevent cutting. Particular attention must be given to the lubrication of the power unit and hoist unit. Detailed lubrication instructions are covered in TM 5–725. Wire rope should be lubricated carefully at intervals to reduce deterioration in accordance with instructions in TM 5–725.

APPENDIX I

REFERENCES

AR 320–5	Dictionary of United States Army Terms.
AR 320–50	Authorized Abbreviations.
DA Pam 310–1	Index of Administrative Publications.
DA Pam 310–3	Index of Doctrinal, Training, and Organizational Publications.
DA Pam 310–4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (Types 4, 6, 7, 8, and 9), Supply Bulletins, Lubrication Orders, and Modification Work Orders.
DA Pam 310–25	Index of Supply Manuals—Corps of Engineers.
FM 5–34	Engineer Field Data.
FM 5–35	Engineers Reference and Logistical Data.
FM 21–30	Military Symbols.
FM 31–72	Mountain Operations.
TM 5–461	Engineer Hand Tools.
TM 5–725	Rigging.
TM 5–9157	Drive Unit, Tramway or Cableway Aerial, Gasoline Driven, Skid Mounted, Blue Island Model 2.

APPENDIX II

TABLES OF USEFUL INFORMATION

Table XVII. Vertical Reactions on Towers

Percent sag	Percent slope	Track cable diameter in inches							
		⅜	½	⅝	¾	⅞	1	1⅛	1¼
1:2 tieback ratio:									
5	0	2, 020	3, 450	5, 300	7, 570	10, 290	13, 430	16, 900	
7.5	0	2, 170	3, 710	5, 680	8, 130	11, 050	14, 430	18, 150	
10	0	2, 320	3, 970	6, 080	8, 690	11, 810	15, 420	19, 400	
10	10	2, 450	4, 190	6, 430	9, 190	12, 490	16, 305	20, 520	
10	20	2, 700	4, 620	7, 070	10, 120	13, 750	17, 960	22, 590	
10	30	2, 930	5, 000	7, 670	10, 970	14, 900	19, 460	24, 480	
10	40	3, 180	5, 440	8, 340	11, 930	16, 200	21, 160	26, 630	
10	50	3, 420	5, 840	8, 950	12, 800	17, 390	22, 710	28, 570	
15	40	3, 420	5, 840	8, 950	12, 800	17, 390	22, 710	28, 570	
1:4 tieback ratio:									
5	0	1, 240	2, 120	3, 240	4, 640	6, 298	9, 130	------	10, 350
7.5	0	1, 400	2, 380	3, 650	5, 220	7, 090	9, 260	------	11, 650
10	0	1, 550	2, 650	4, 055	5, 810	7, 890	10, 300	------	12, 960
10	10	1, 800	3, 080	4, 720	6, 750	9, 171	11, 980	------	15, 070
10	20	2, 060	3, 510	5, 380	7, 700	10, 460	13, 670	------	17, 190
10	30	2, 340	4, 000	6, 130	8, 770	11, 915	15, 560	------	19, 580
10	40	2, 590	4, 430	6, 790	9, 710	13, 190	17, 230	------	21, 680
10	50	2, 660	4, 550	6, 970	9, 980	13, 550	17, 690	------	22, 260
15	40	2, 660	4, 550	6, 970	9, 980	13, 550	17, 690	------	22, 260

Table XVIII. Weight and Breaking Strength of Wire Rope in Tons

Diameter (in.)	Improved plow steel rope					
	6 x 7		6 x 19		6 x 37	
	Weight per foot (lb)	Breaking strength (tons)	Weight per foot (lb)	Breaking strength (tons)	Weight per foot (lb)	Breaking strength (tons)
¼	0. 094	2. 64	0. 10	2. 74	0. 10	2. 5
⅜	. 21	5. 86	. 23	6. 3	. 22	5. 7
½	. 38	10. 3	. 40	10. 8	. 39	10. 2
⅝	. 59	15. 9	. 63	16. 6	. 61	15. 8
¾	. 84	22. 7	. 90	23. 7	. 87	22. 6
⅞	1. 15	30. 7	1. 23	32. 2	1. 19	30. 6
1	1. 50	39. 7	1. 60	42. 0	1. 55	39. 8
1⅛	1. 90	49. 8	2. 03	53. 0	1. 96	50. 1
1¼	2. 34	61. 0	2. 50	65. 0	2. 42	61. 5

Table XIX. Holding Power of Deadmen in Ordinary Earth

Mean depth of anchorage in feet	Inclination of pull (vertical to horizontal), and safe resistance in pounds per square foot of projected area of deadman				
	Vertical	1/1	1/2	1/3	1/4
3	600	950	1, 300	1, 450	1, 500
4	1, 050	1, 750	2, 200	2, 600	2, 700
5	1, 700	2, 800	3, 600	4, 000	4, 100
6	2, 400	3, 800	5, 100	5, 800	6, 000
7	3, 200	5, 100	7, 000	8, 000	8, 400

APPENDIX III

GRAPHS FOR DESIGN OF EXPEDIENT CABLEWAYS

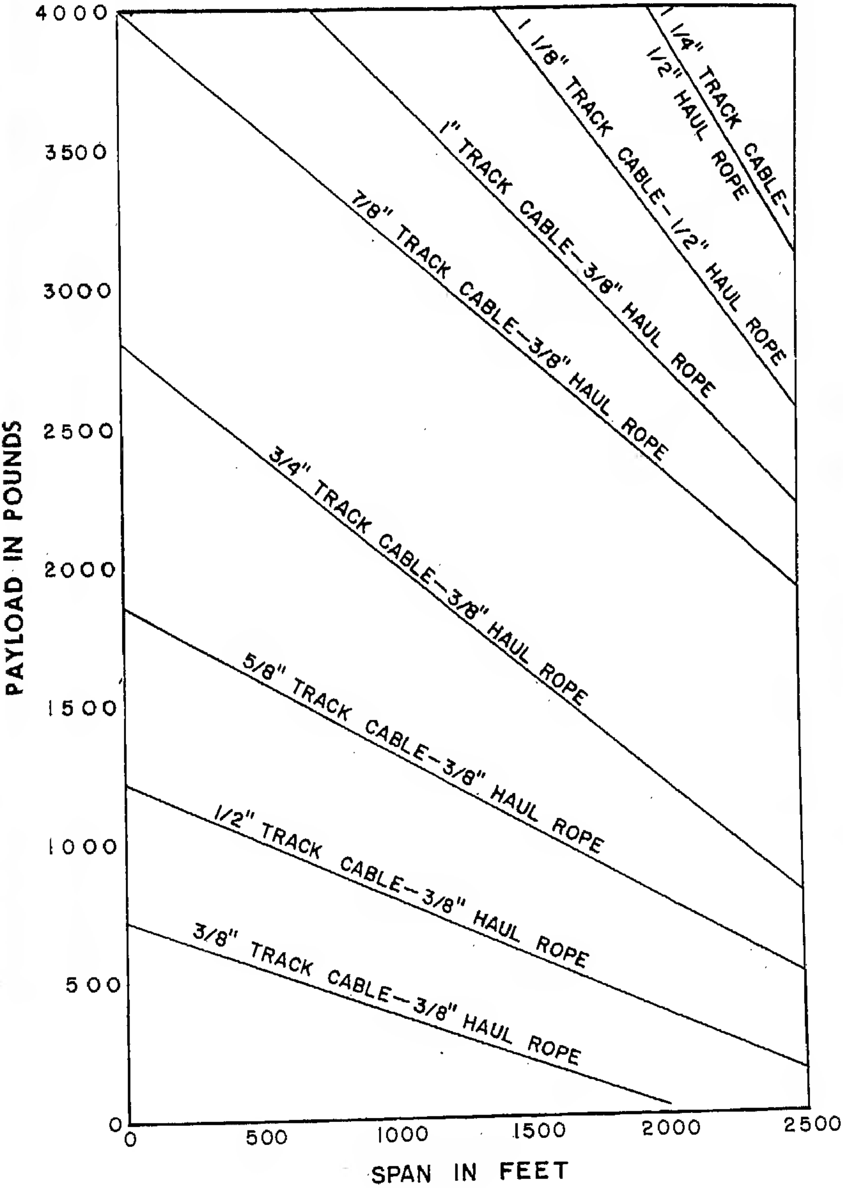


Figure 149. Graph showing upper load limits for track cables and haul ropes with 5 percent sag and 0 percent slope.

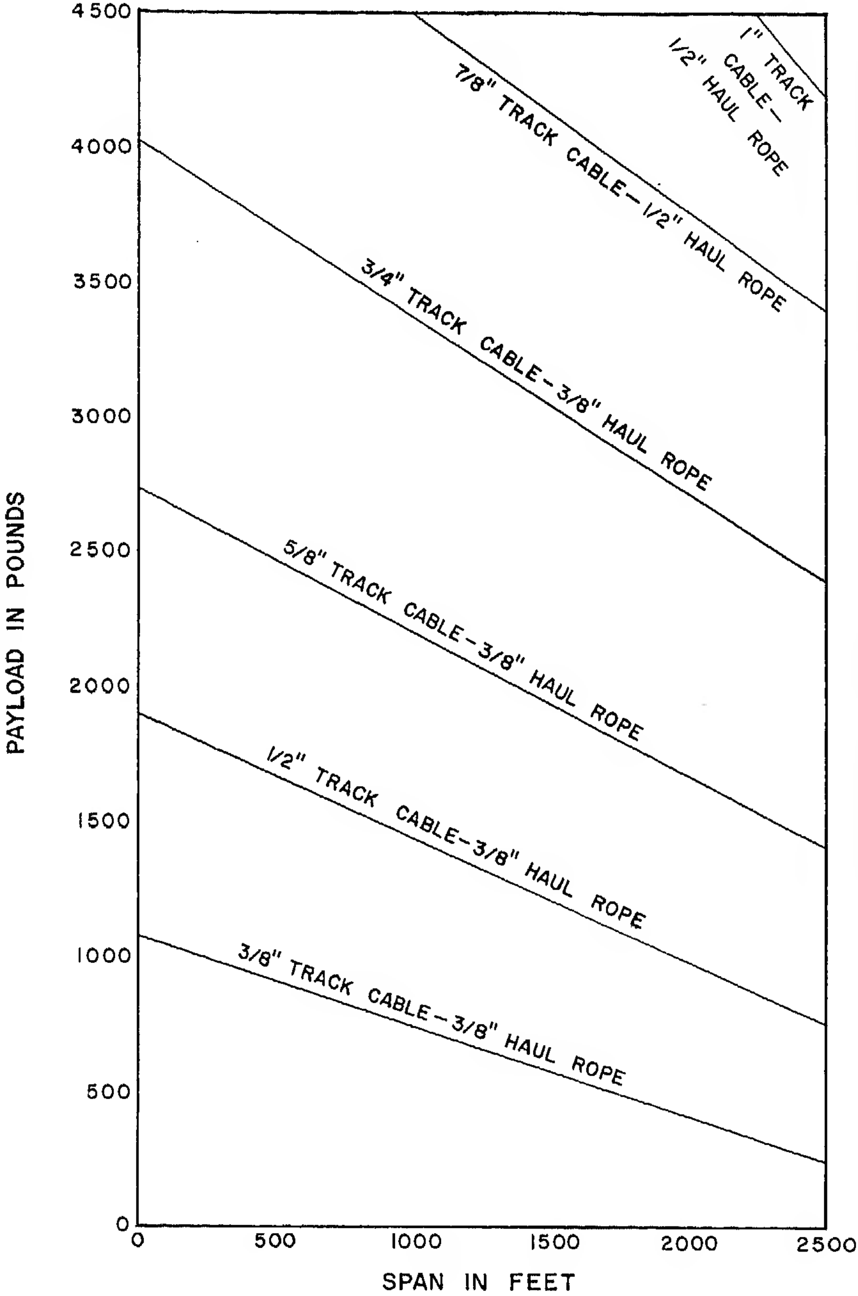


Figure 150. Graph showing upper load limits for track cables and haul ropes with 7.5 percent sag and 0 percent slope.

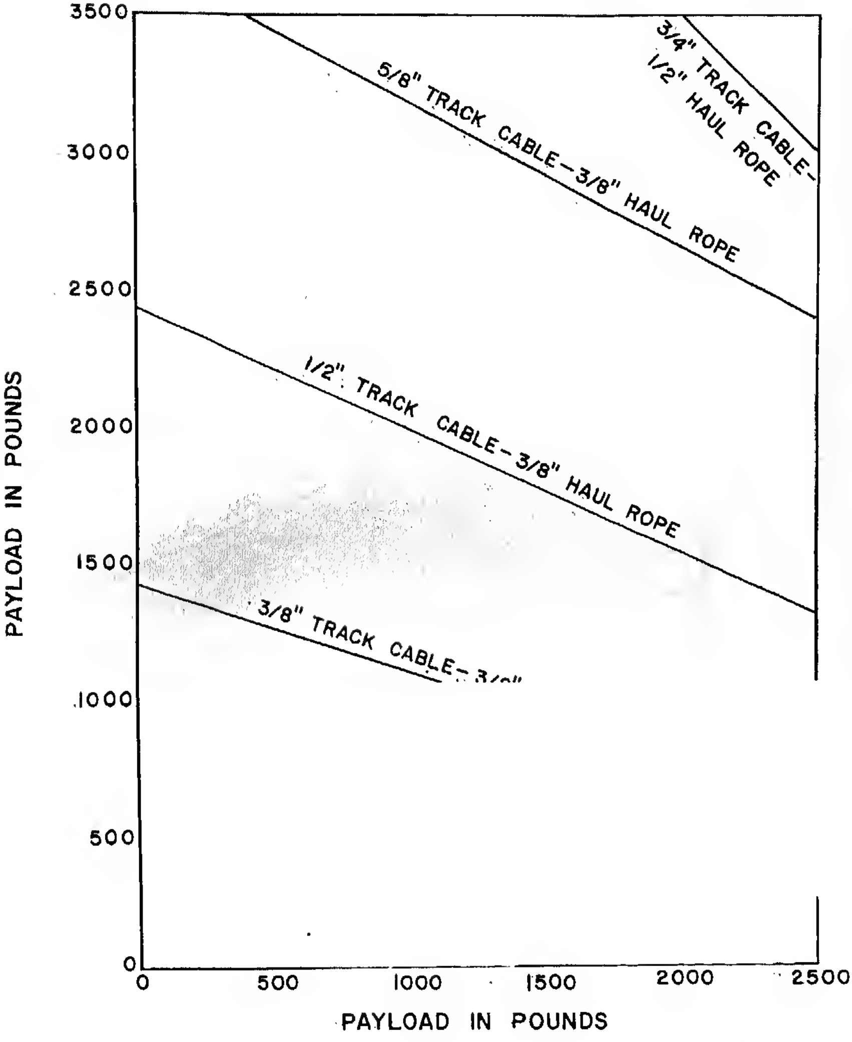


Figure 151. Graph showing upper load limits for track cables and haul ropes with 10 percent sag and 0 percent slope.

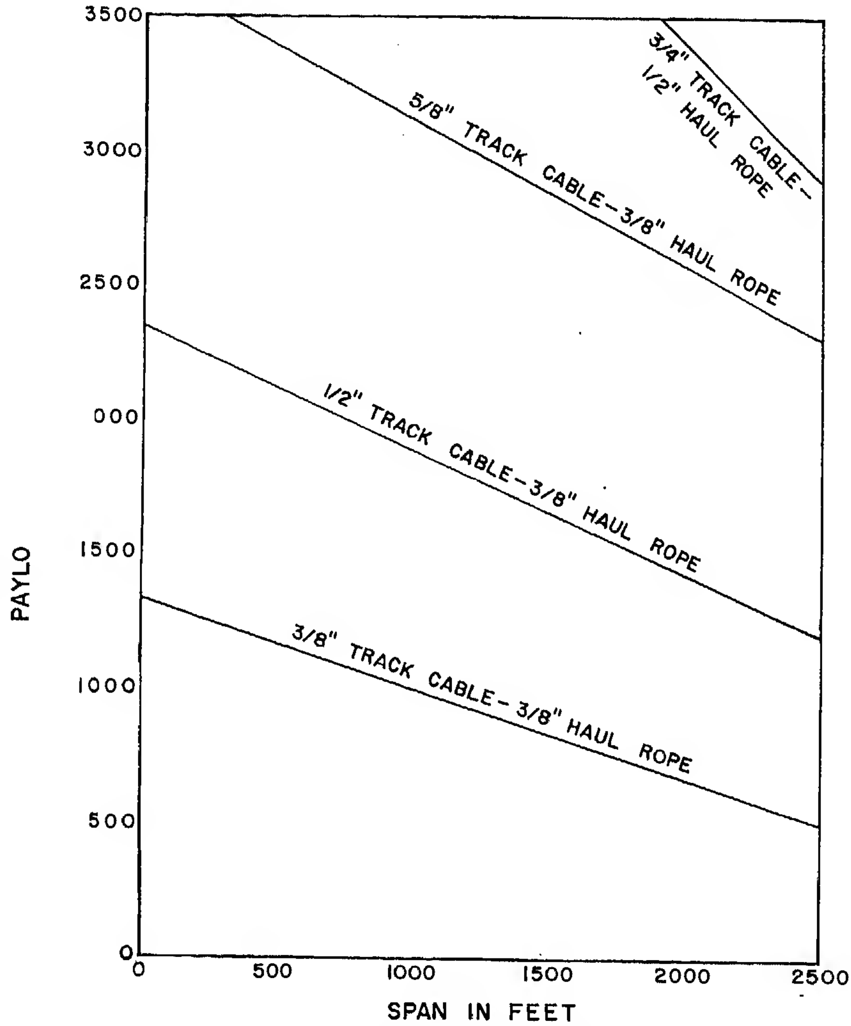


Figure 152. Graph showing upper load limits for track cables and haul ropes with 10 percent sag and 10 percent slope.

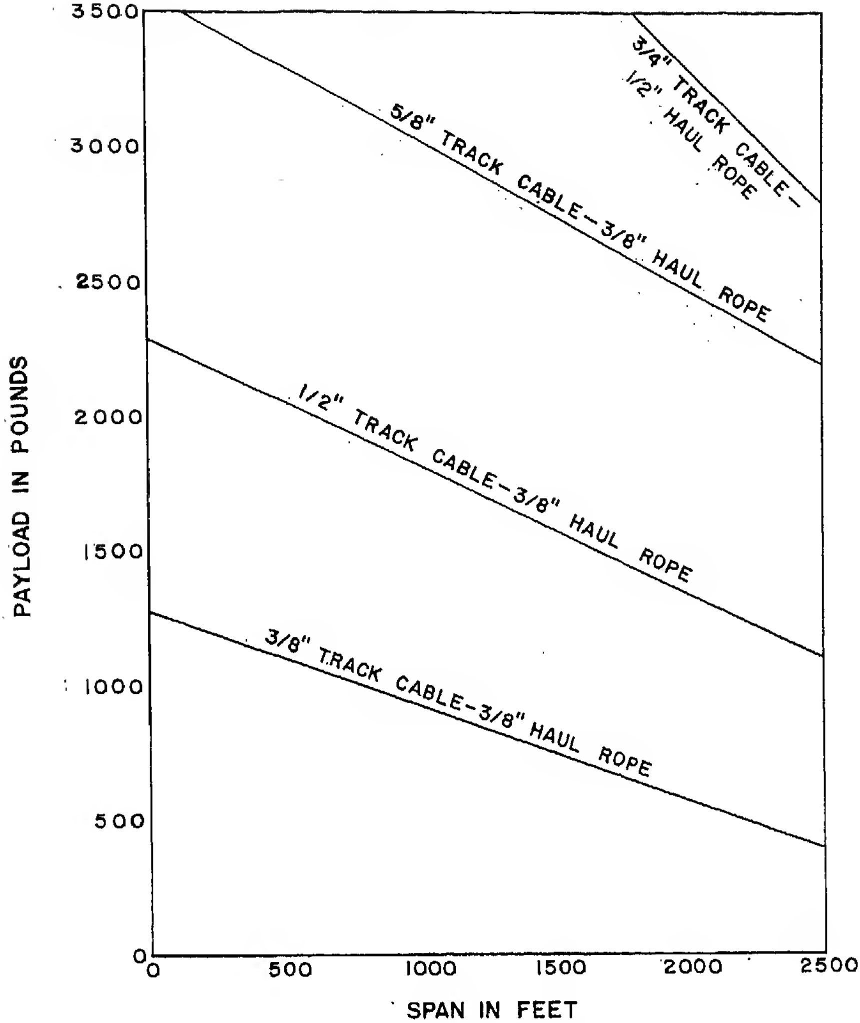


Figure 153. Graph showing upper load limits for track cables and haul ropes with 10 percent sag and 20 percent slope.

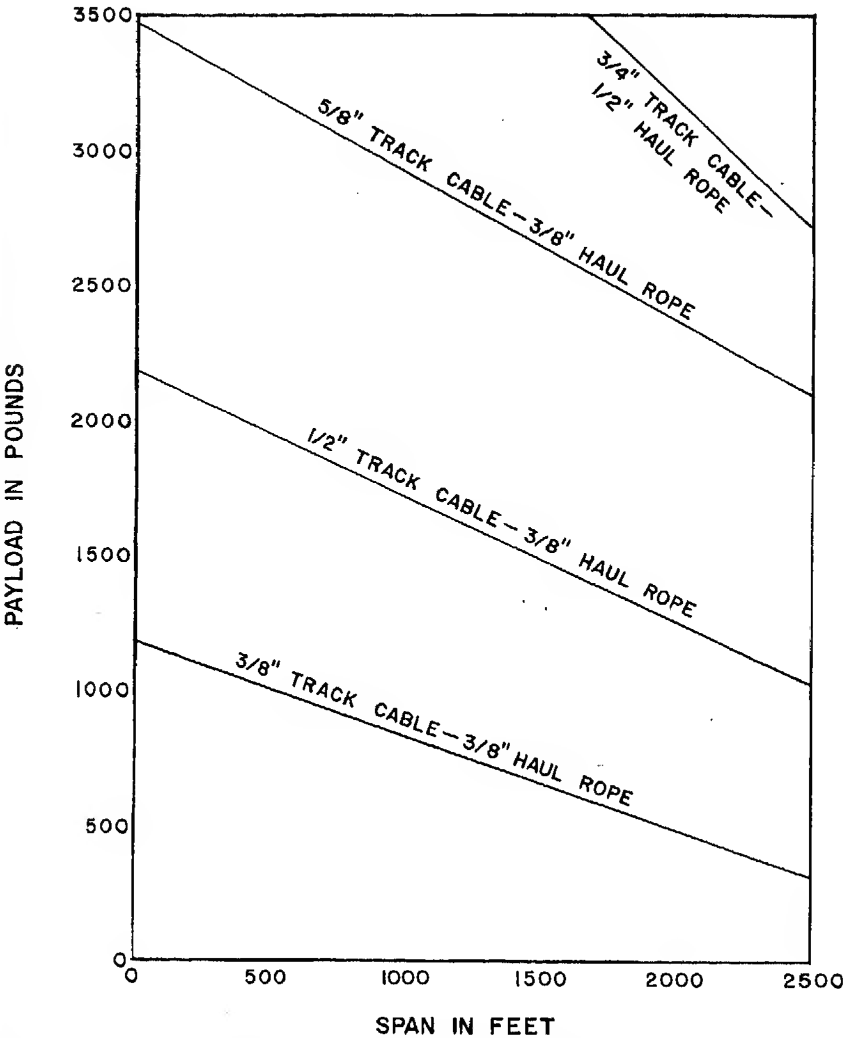


Figure 154. Graph showing upper load limits for track cables and haul ropes with 10 percent sag and 30 percent slope.

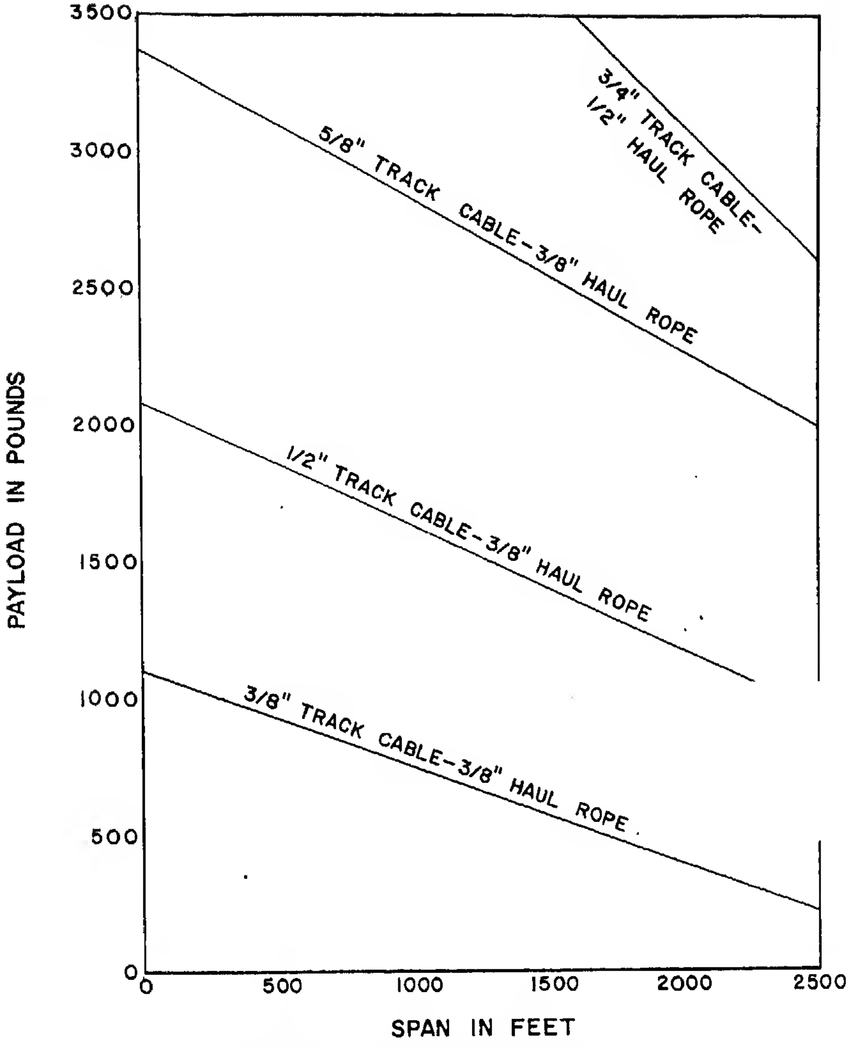


Figure 155. Graph showing upper load limits for track cables and haul ropes with 10 percent sag and 40 percent slope.

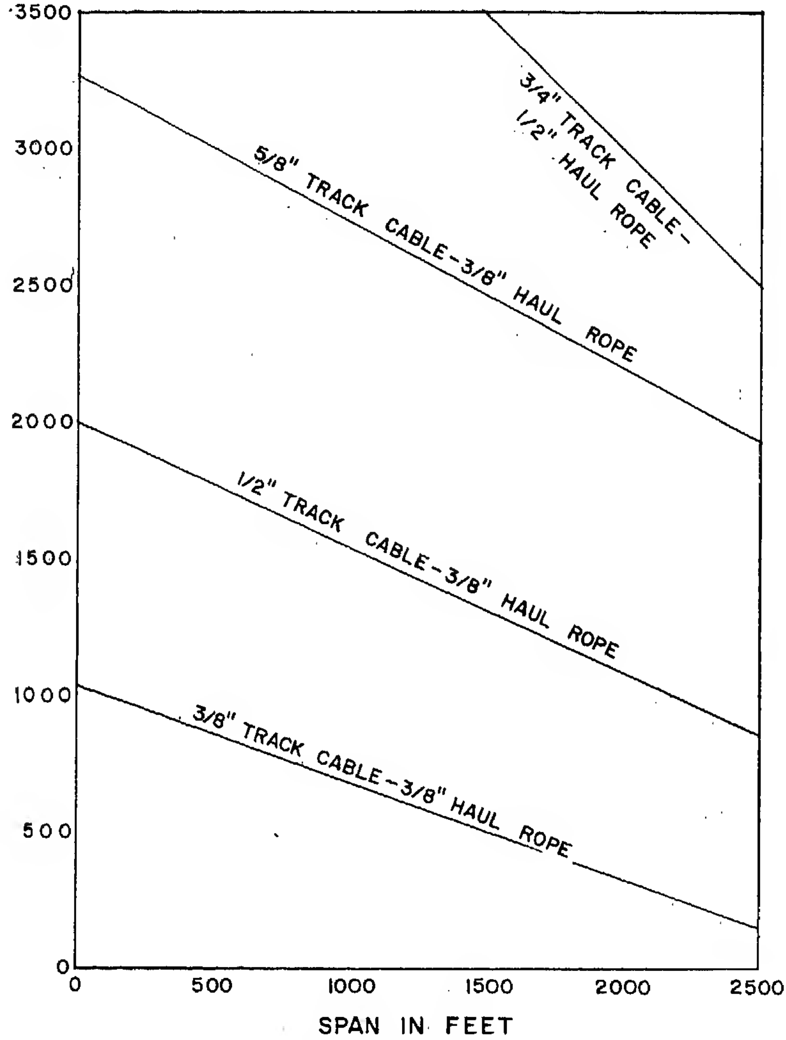


Figure 156. Graph showing upper load limits for track cables and haul ropes with 10-percent sag and 50 percent slope.

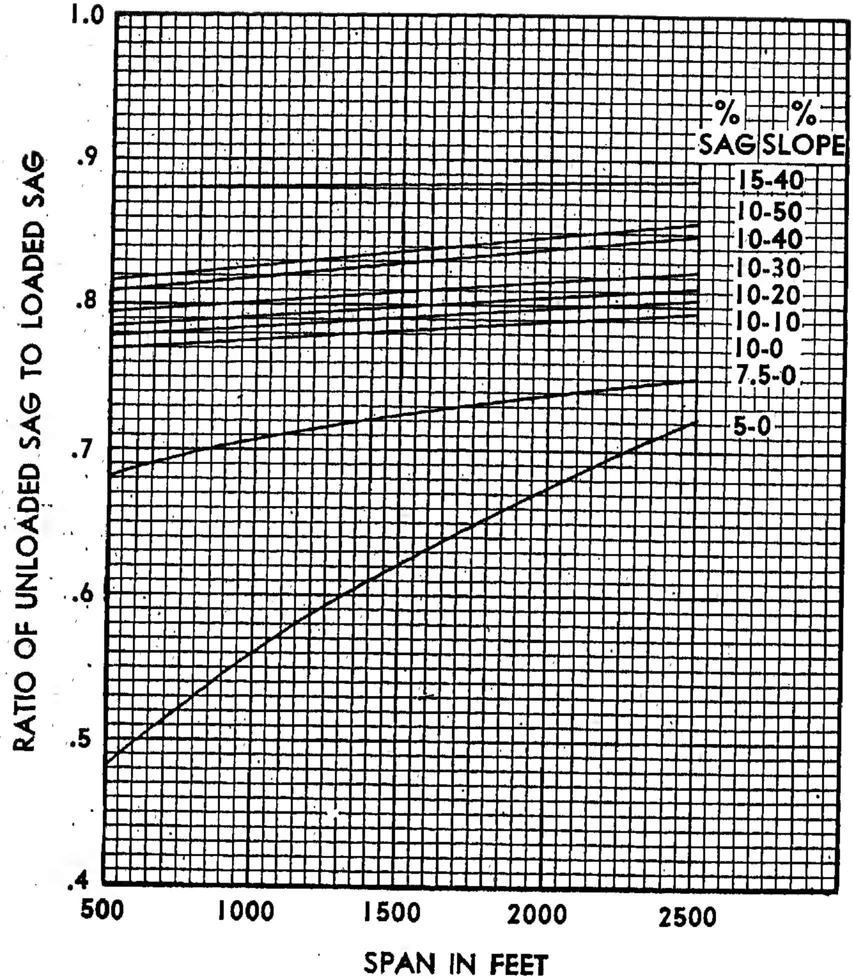


Figure 158. Relation of unloaded sag in track cables to loaded sag.

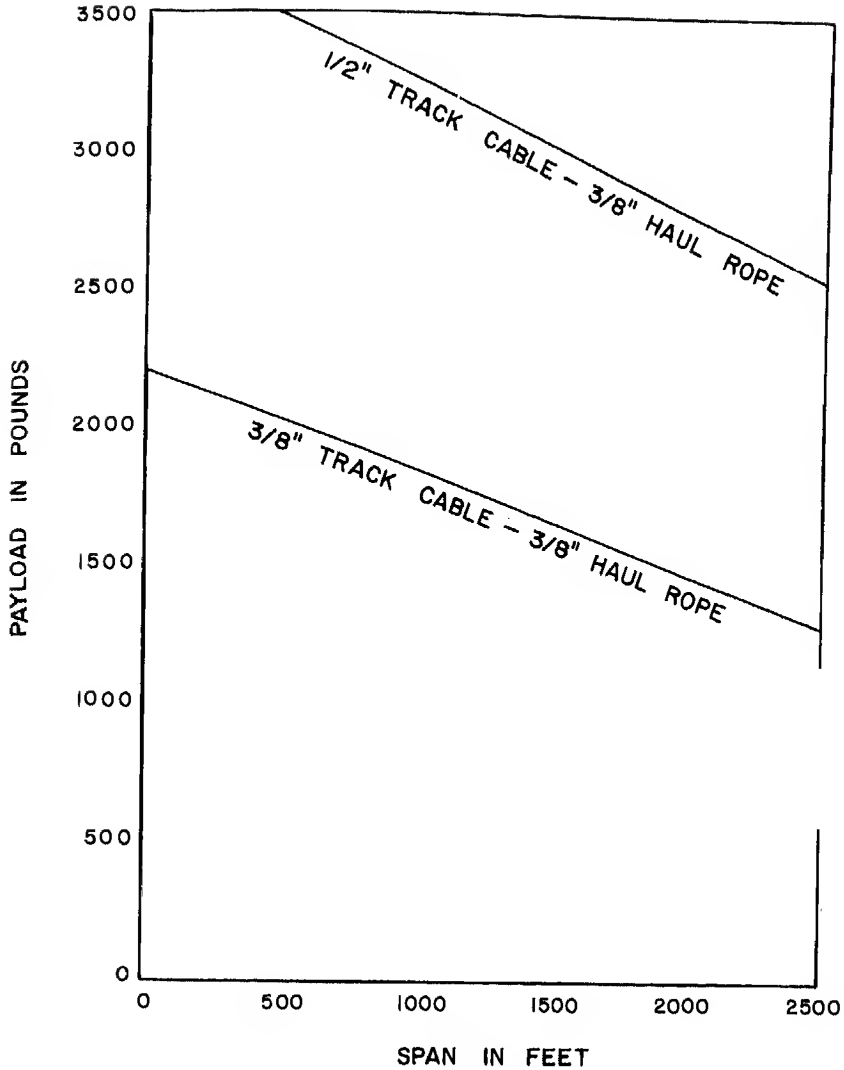


Figure 157. Graph showing upper load limits for track cables and haul ropes with 15 percent sag and 40 percent slope.

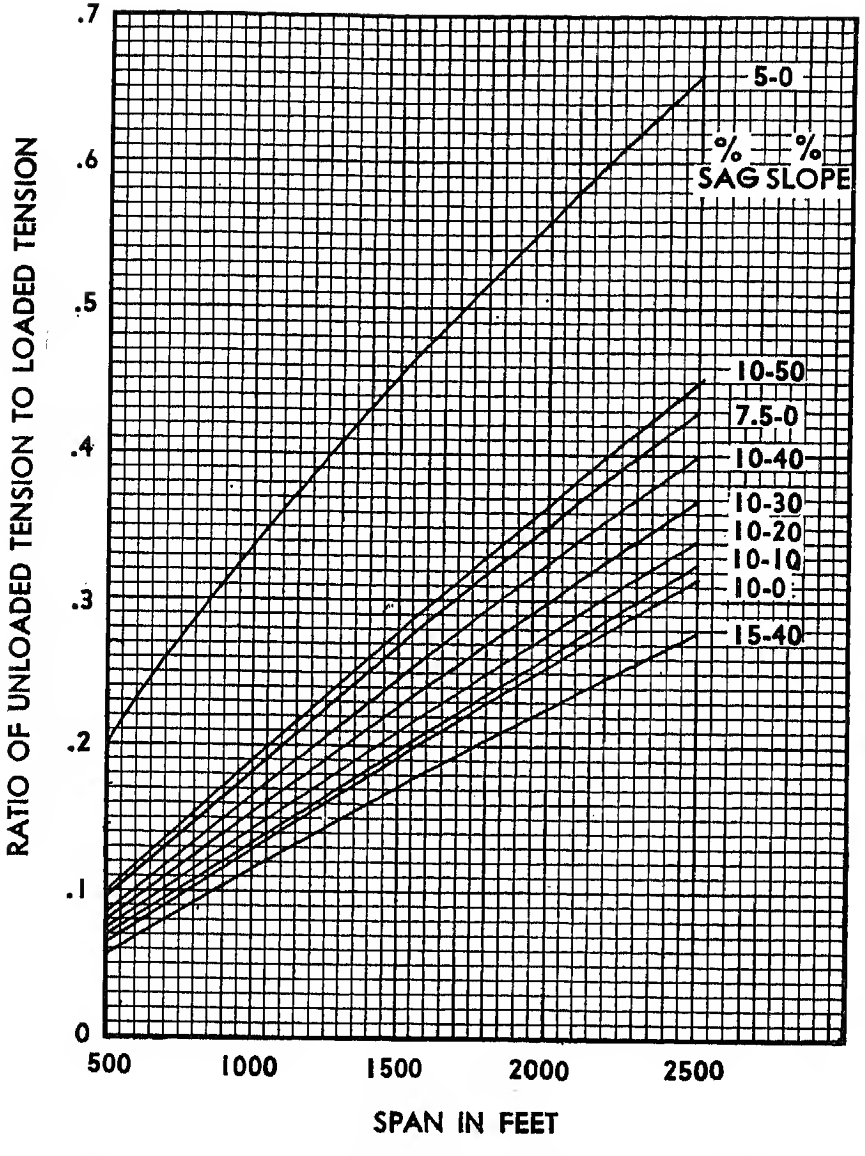


Figure 159. Relation of unloaded tension in track cables to loaded tension.

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